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THE

BOMBAY ENGINEERS' REPORT

FOR THE

OFFICIAL YEAR 1851-52.

COMPRISING

REPORTS FROM LIEUTENANT COLONEL WALTER SCOTT; MAJOR H. B. TURNER; CAPTAINS J. J. F. CRUICKSHANK, C. W. TREMENHEERE, W. S. SUART, B. R. POWELL, T. L. JAMESON, AND W. D. GRAHAM; LIEUTENANTS M. K. KENNEDY, W. R. DICKINSON, C. NASMYTH, R. LAURIE, AND J. G. FIFE; AND MR. T. P. ARMITSTEAD.

Bombay:

PRINTED AT THE

BOMBAY EDUCATION SOCIETY'S PRESS.

1853.

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Names of Works.				Total.		
				Rs.	*a.*	*p.*
Brought forward, Rupees	1,065	8	0	53,028	10	5
Petty repairs to the buildings in the Judicial Department	1,598	8	0	2,664	0	0
Other works				2,478	0	9
New buildings				1,468	0	0
TERRITORIAL DEPARTMENT.						
Annual repairs to the buildings in the Territorial Department, for 1851-52 .. .. Rs.	1,327	0	0			
Petty repairs to the buildings in the Territorial Department	250	4	3	1,577	4	3
Other works...				402	0	0
ECCLESIASTICAL DEPARTMENT.						
Annual repairs to the buildings in the Ecclesiastical Department, for 1851-52. .. Rs.	286	0	0			
Petty repairs to the buildings in the Ecclesiastical Department	578	5	0	864	5	0
Other works				979	0	0
New buildings				352	0	0
MARINE DEPARTMENT.						
Annual repairs to the buildings in the Marine Department, for 1851-52 .. .. Rs.	1,946	0	0			
Petty repairs to the buildings in the Marine Department..	1,465	1	8	3,411	1	8
Other works				289	0	0
MILITARY DEPARTMENT.						
Annual repairs to the public buildings occupied by Troops, &c. in the Castle, Fort George Garrison, on the Esplanade, on Colaba, and at Outposts .. .. .. Rs.	25,110	6	0			
Petty repairs to the public buildings occupied by Troops, &c. in the Castle, Fort						
Carried forward, Rupees	25,110	6	0	67,513	6	1

Names of Works.				Total.		
				Rs.	*a.*	*p.*
Brought forward, Rupees	25,110	6	0	67,513	6	1
George Garrison, on the Esplanade, on Colaba, and at Outposts	10,029	5	4			
				35,139	11	4
Other works..	..	..	..	82,258	8	4
Miscellaneous works ..	..	..	..	12,533	15	4
Including—						
Levelling the Esplanade, supplying water to the dhobees, annual repairs to the Dhobee-wada, &c., covering the rubbish with sand near the Colaba causeway, and expenses in collecting the fees, &c.	7,550	12	6			
Total expenditure, rupees one lac, ninety-seven thousand, four hundred and forty-five, annas nine, and pie one.. ..				1,97,445	9	1

Statement of the Sums expended by the Garrison Engineer and Civil Architect at the Presidency, from 1st May 1851 to 30th April 1852.

Names of Officers.	Annual and Petty Repairs.	Certain Works.	Buildings.	Expended from Esplanade Fund.	Expended for Artificers and Labourers engaged for, or returning from, Out-stations, &c.	Total.
	Rs. a. p.	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*
Captain J. Estridge, Garrison Engineer and Civil Architect; Captain C. W. Tremenheere, Officiating Garrison Engineer and Civil Architect; and Captain J. J. F. Cruickshank, Garrison Engineer and Civil Architect at the Presidency.						
General Department	17,438 3 3	20,130 1 5	15,460 5 9	....	....	53,028 10 5
Judicial ditto	2,664 0 0	2,478 0 9	1,468 0 0	....	....	6,610 0 9
Territorial ditto	1,577 4 3	402 0 0	....	....	....	1,979 4 3
Ecclesiastical ditto	864 5 0	979 0 0	352 0 0	....	....	2,195 5 0
Marine ditto	3,411 1 8	289 0 0	....	....	....	3,700 1 8
Military ditto	35,139 11 4	11,417 2 7	70,841 5 9	7,550 12 6	4,983 2 10	1,29,932 3 0
Grand Total	61,094 9 6	35,695 4 9	88,121 11 6	7,550 12 6	4,983 2 10	1,97,445 9 1

J. J. F. CRUICKSHANK, Captain,
Garrison Engineer and Civil Architect at the Presidency.

MARINE DEPARTMENT.

Statement showing the Actual Expenditure upon Works carried on under the Engineer to the Dockyard, during the Official Year from 1*st May* 1851 *to* 30*th April* 1852.

Bombay, Dockyard Engineer's Office, 1*st May* 1852.

Names of Works.		Total.
		Rs. a. p.
New works..		57,570 9 5
Including—		
Construction of a portion of the work connected with the proposed Basin and Breakwater ..	22,045 4 0	
Repairs to the fortifications and buildings		6,997 5 2
Emergent works executed		421 11 4
Total..Rupees		64,989 9 11

Comparative Statement of Expenditure and Establishment in the Marine Department under the Engineer to the Dockyard, from 1*st May* 1851 *to* 30*th April* 1852.

Bombay, Dockyard Engineer's Office, 30*th October* 1852.

Staff salary	Rs.	7,200	0 0
Regimental allowances, less net pay		3,523	8 0
Permanent establishment		2,849	14 11
		13,573	6 11
Other expenditure		64,989	9 11
Gross expenditure		78,553	0 10
Per-centage of staff salary and establishment, less net pay, on gross expenditure		17,278	0 0

C. W. TREMENHEERE,
Engineer to the Dockyard.

No. 81 of 1853.

Military Department.

To the Secretary to the Military Board,

Bombay.

Commanding Engineer's Office, Aden, 12th February 1853.

Sir,

I have the honor to send tracings of the drawbridges over the ditch of the Isthmus line of works, as requested by the Military Board, for publication in the Bombay Engineers' Report for the year 1851–1852, should there be no objection thereto.

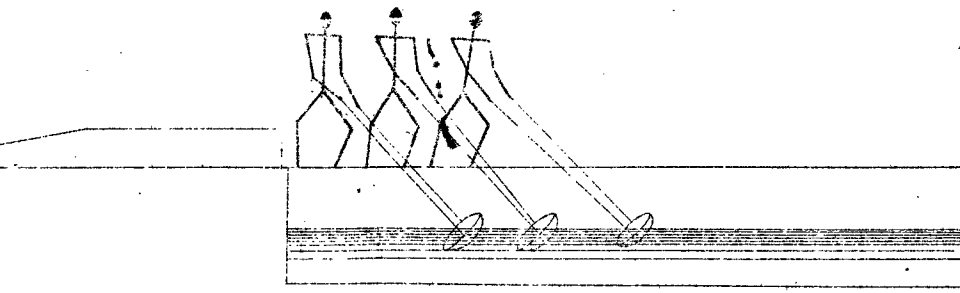
2. The drawbridge was designed by Colonel Waddington, C. B. It was found, however, necessary to make the escarp from the bridge to the top of the parapet perpendicular, instead of with a batter of 1 in 8, as originally designed, and as in the rest of the escarp. An iron axle turning in brass plummer blocks has also been added ; the wooden gudgeons first made having too much friction to turn in the stone beds cut for them.

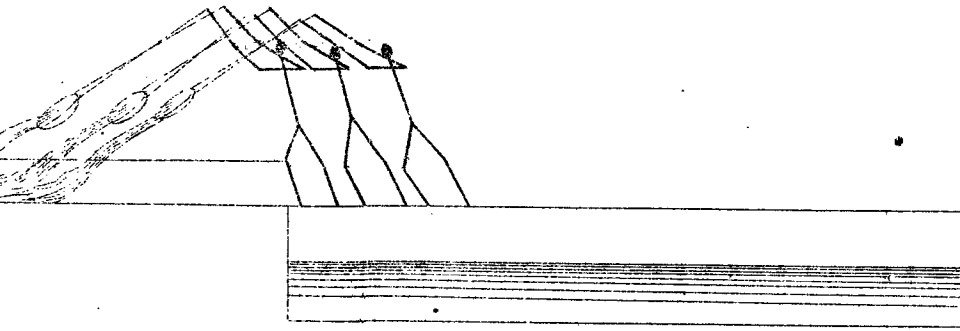
3. The escarp was made perpendicular, because it was found, in raising the bridge, that after passing the centre it fell against the wall with a shock that was felt sensibly by a person standing on the banquette ; and because great difficulty, amounting almost to an impossibility, was experienced in pushing the bridge back over its centre, when it was required to be lowered.

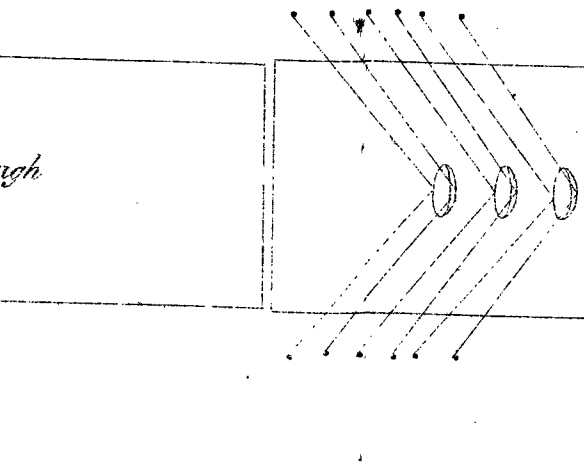
4. The bridge under Jibbel Hudeed, which was originally fitted with an iron axle, now that the wall is perpendicular, can be raised and lowered with facility : the weight of the two counterpoise rollers is 2,800 lbs. ; the gudgeons of the iron axle are 3 inches in diameter.

5. The level of the bridge being 9 feet above that of

shewing the Method of bailing water from the foundations of the Works in







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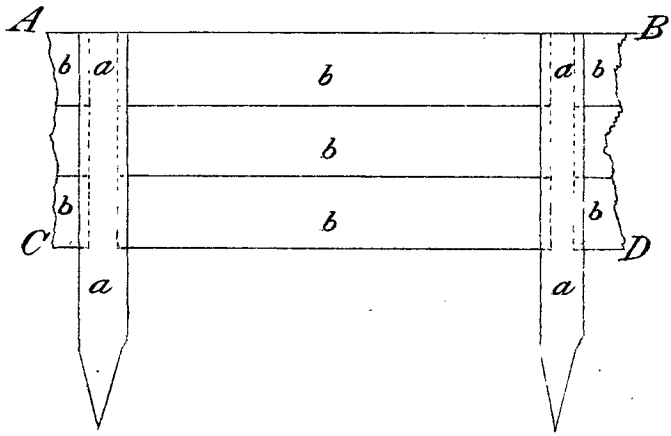
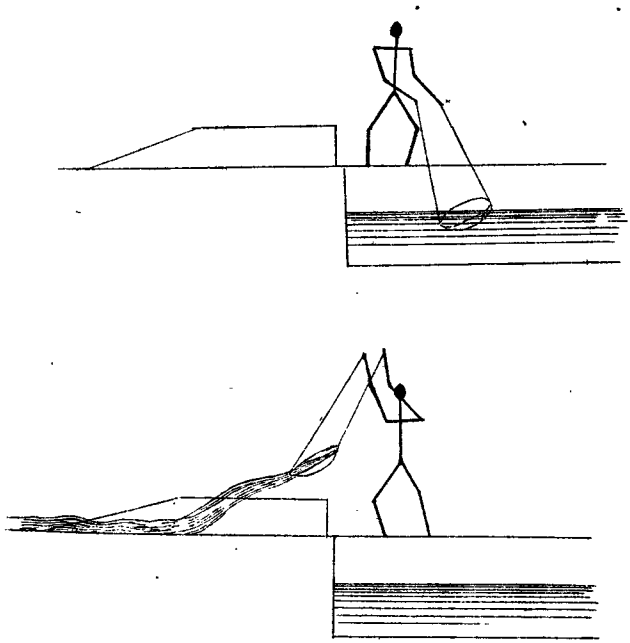
Foundation to be drained

Sketch 1.



Sketch 2.



the ground at the Isthmus, the long passage leading to it, shown in the plan as within the mass of rampart, was necessary, that the road to it should be of a moderate slope.

6. The section also shows the section of the ditch as made throughout the Isthmus line of works, with the invert arch and beton foundation. The level of the water under the Isthmus is also the level of the bottom of the ditch; the invert and beton are always under water, and the sand forming the Isthmus being in some places very soft and fine, it was found necessary, therefore, in carrying out the work, to retain the sides of the excavation with piles and planks, as in Sketch 1, in which *a a* are the piles; *b b b* the planks between them, fitting into grooves in the piles; A B the surface of the water or level of bottom of ditch; C D the bottom of the excavation: the piling was only used at the sides, the beton and invert being made in bays, separated by a masonry wall built on the beton, across the line of the ditch. The method adopted (Sketch 2) to bale out the water was with baskets lined with leather, to which four strings were attached, when two men, one on each side of a trench running out from the side of the excavation, and cut on purpose, lifted the water into a wooden trough, from which it was conveyed away in a channel, and allowed to sink in the sand: three pairs of men, with practice, could stand side by side, and bale with baskets, delivering the water into the same troughs. I have shown in a sketch on the annexed sheet the trough and trench, being supposed in section. This method of baling was found more economical than any other, and very successful and expeditious: as many men as were necessary could be employed at the same time; and when the excavation was too deep for one lift, which it was under the hills, the water was lifted twice, by another set of men working above, and at a little distance from the other.

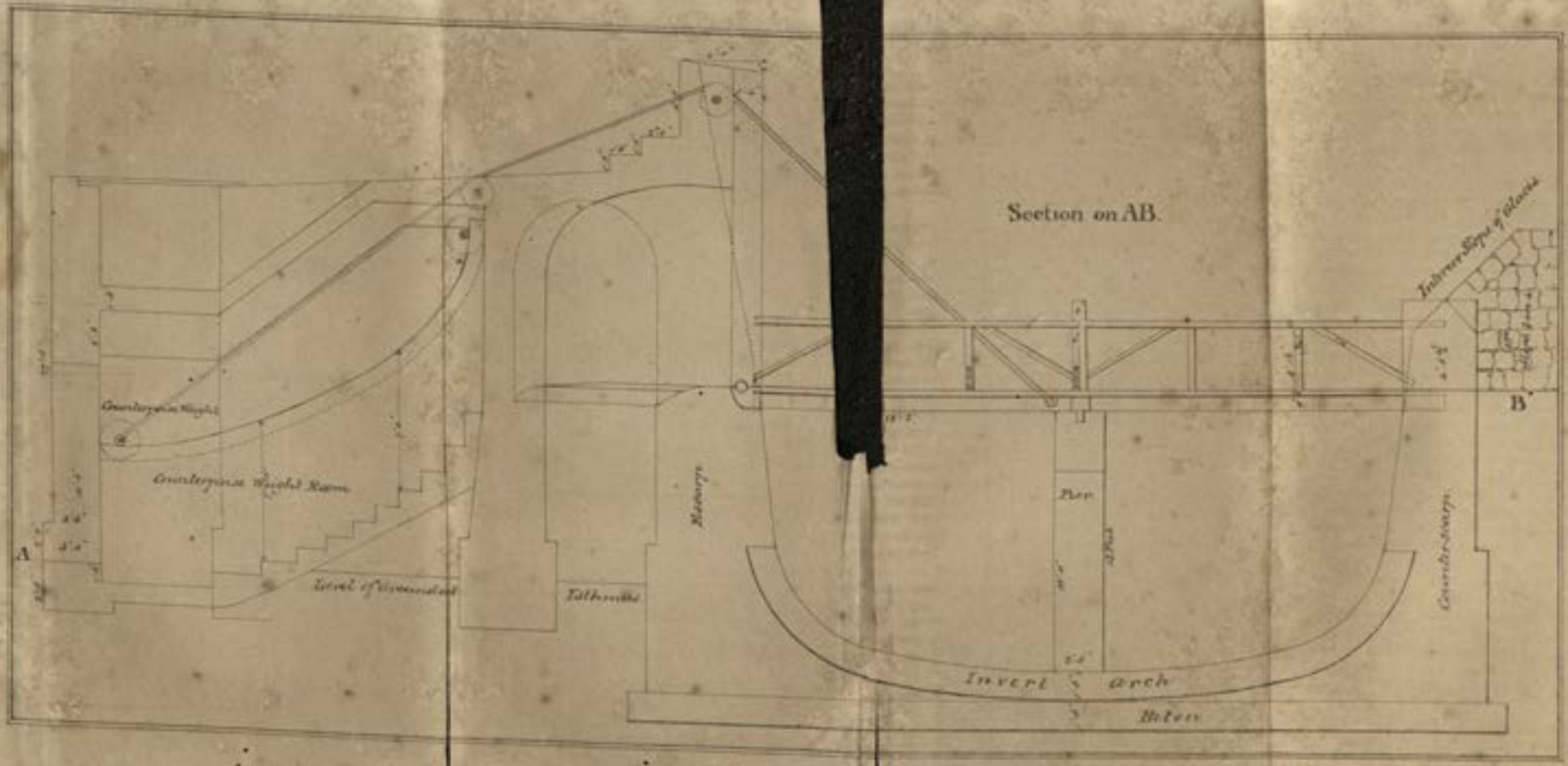
7. The pile-driving machines are two in number, on four wheels, running on sleepers with edge rails fixed along them. The sleepers, four in number for each engine, were laid on

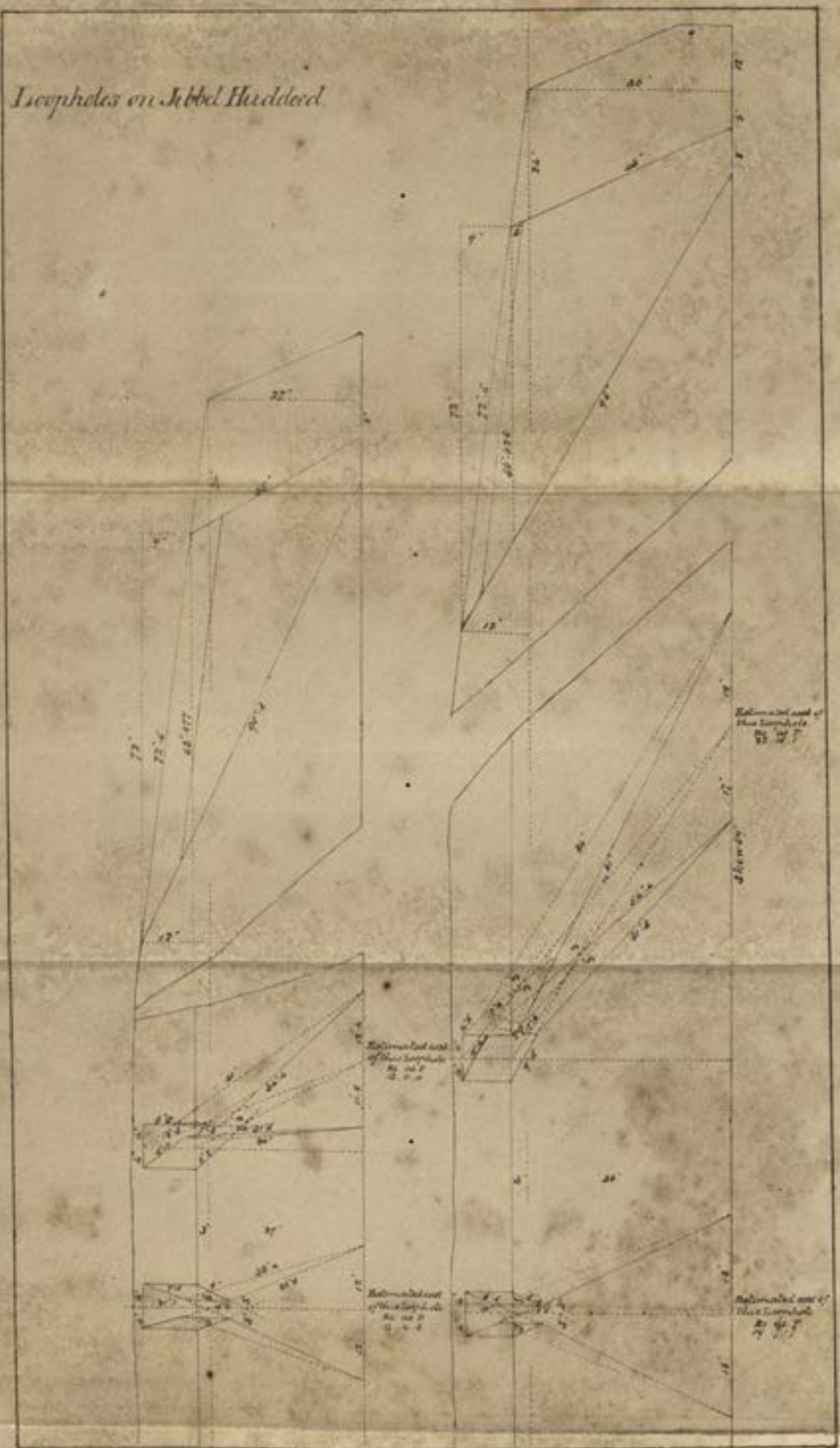
either side of the proposed line of piling, so that the machine could readily advance along it (the sleepers passed over being carried to the front); the machine had trunks, into which the pile to be driven was put, under the monkey, which last worked in the trunk, and was moved by a rope over a pulley, the use of the trunk being as a guide for the monkey (a piece of iron ship's ballast), and to prevent the pile twisting. The whole apparatus answered very well.

8. The invert arch, in experiments now in progress, has proved a most formidable auxiliary for the defence of the ditch—cannister fired along it, with low charges, and at a low elevation, from an 8-inch short 50 cwt. gun, recochetting along the ditch in every direction. Had there been no invert, nine-tenths of the shot would have been buried in the sandy bottom of the ditch, and, therefore, without the invert, it would have been difficult to have effectually flanked the ditch; as large charges sufficient to carry the cannister to the salients without grazing cannot be used without great injury to the masonry, and much elevation cannot be given, as the cannister shot would spread over the parapet: as it is, the fire from the 8-inch gun with cannister shot is most formidable, sweeping the ditch from 40 yards from the muzzle of the gun in a very effective manner. Within forty yards the grape passes as a ball, but this ground is defended by numerous loop-holes in the parapets of the retired flank gorge wall of bastions, and of curtains; and in the right redan and demi-bastions 20 feet of this 40 yards is occupied by a cunette ditch, that effectually prevents the embrasures from being entered.

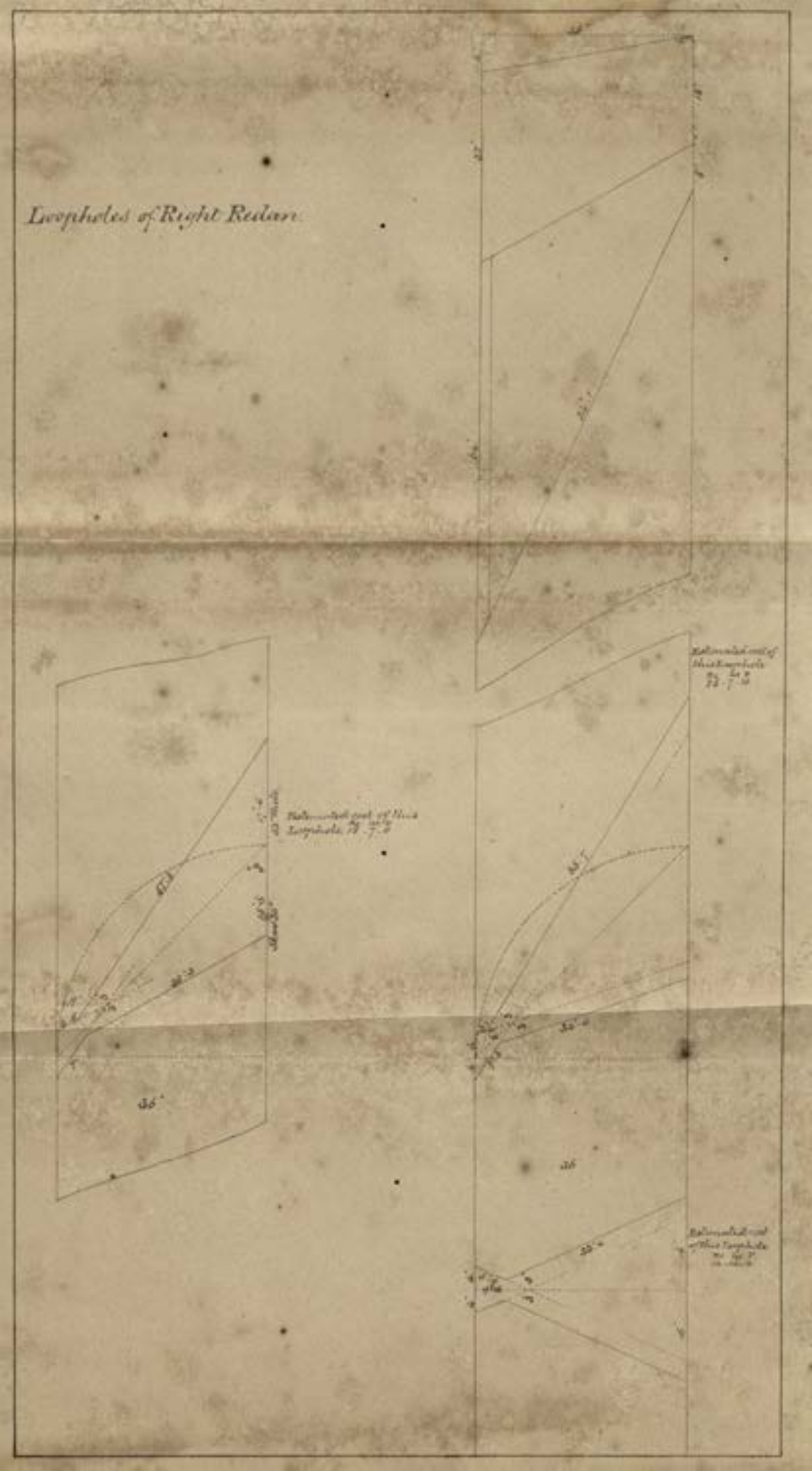
9. I also annex two tracings of loop-holes as made in the gateway redan, and on Jibbel Hudeed; the parapet being perpendicular in the former, but having exteriorly a batter of 1 in 8 in the latter. The plans and estimate of their cost were made by Colonel Waddington, C. B., when Commanding Engineer.

10. The tracings show everything connected with the

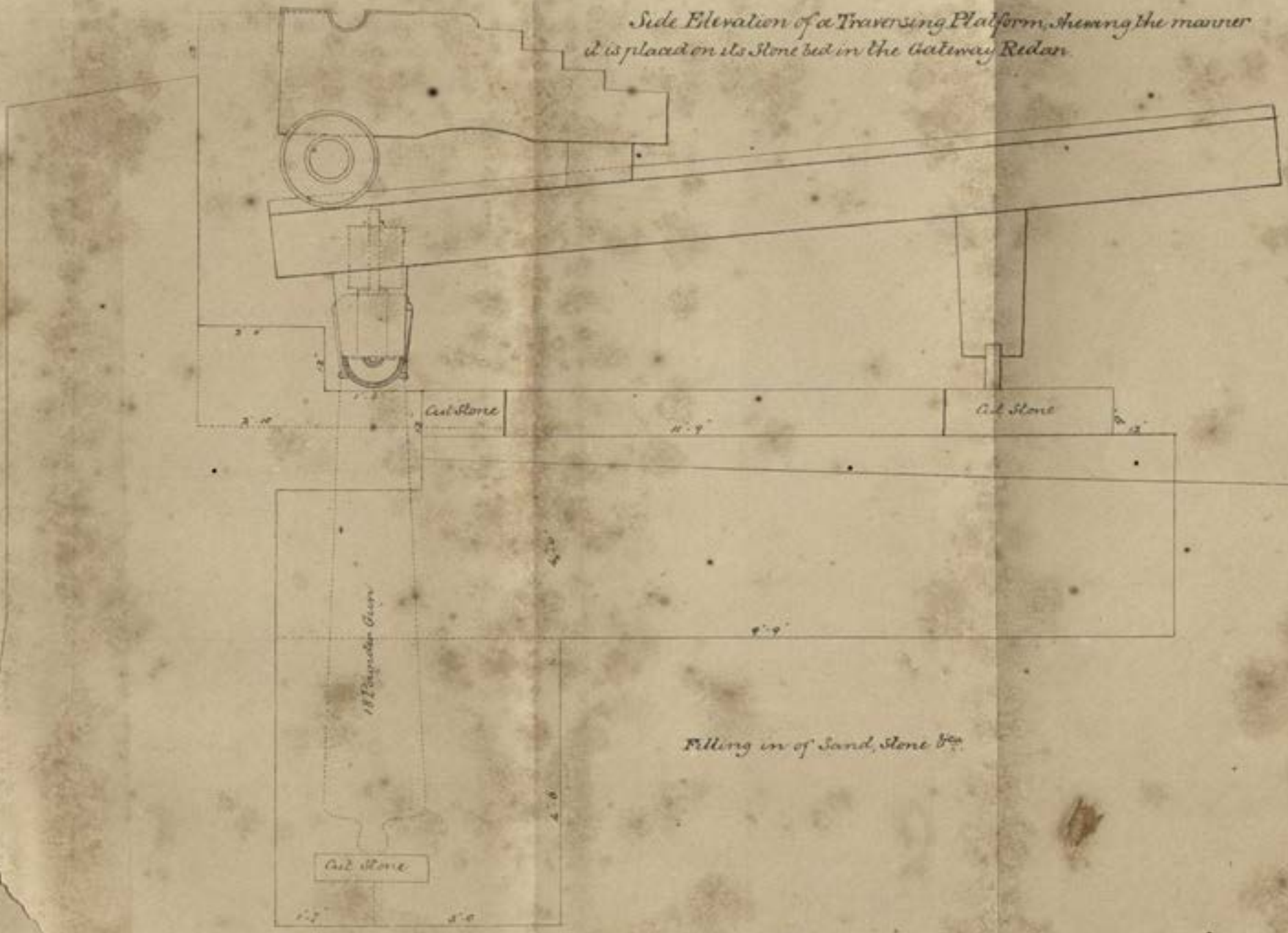

Section on AB.
Counterpoise Weight
Counterpoise Weight Room
Level of Commencement
Tailbreadth
Recess
Pier
Pier
Invert Arch
Batter
Counterpoise
Inverse Slope of Glacis
A
B

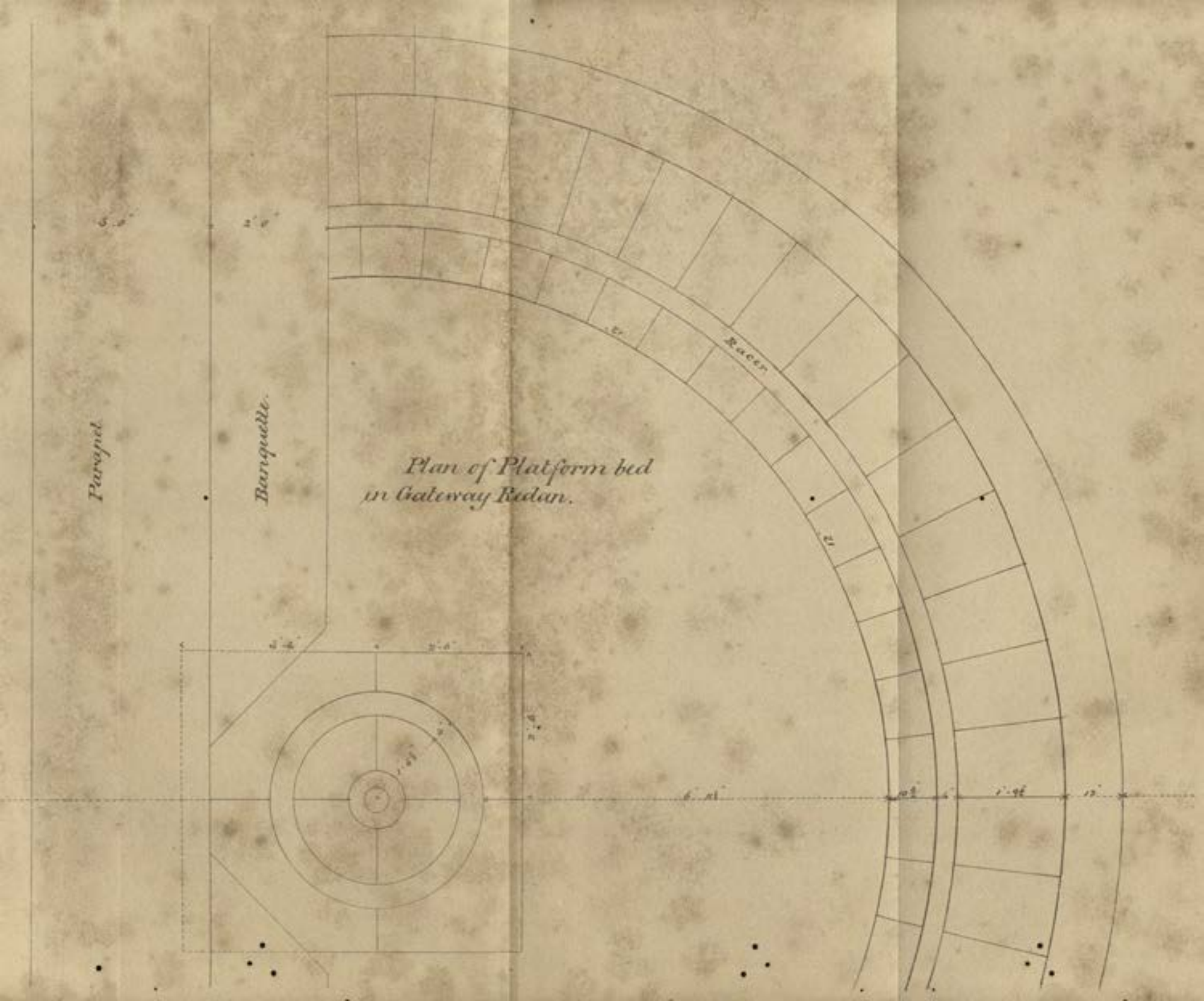

Loopholes on Jubbel Huddeed

Loopholes of Right Redan



Side Elevation of a Traversing Platform, shewing the manner it is placed on its Stone bed in the Gateway Redan




Parapet.
Banquette.
Racer
Plan of Platform bed
in Gateway Redan.

loop-holes very clearly, and it is only necessary here to draw attention to the much greater complexity of construction in loop-holes of nearly similar external openings in a wall with an external batter like that of Jibbel Hudeed, especially when the loop-holes are askew.

11. I also annex a side elevation of a traversing platform, with a plan of its stone bed, showing the manner it is placed on the bed in the gateway redan.

12. The iron racers are screwed to the stone beds, holes being made at the necessary intervals in the stones, and filled with lead to hold the screws.

I have the honor to be,

Sir,

Your most obedient Servant,

W. S. SUART, Captain,

Commanding Engineer, Aden.

Notes extracted from a Memorandum by Lieutenant J. C. ANDERSON, *of the Madras Engineers, of the formation of the Tunnel through the Hill of Ras-el-Girreff, at Aden.*

The tunnel through Ras-el-Girreff was commenced on the 10th June 1845; from which date until the 15th August, a party of Madras sappers and miners was employed in scarping the side of the hill on the *left*, or north-west end, for the purpose of getting a clear face for the entrance. The driftway was commenced on the 15th August 1845. The work at the right or south-east was not commenced until some time afterwards. The date on which the scarping at the side of the hill was commenced cannot be ascertained, but the driftway was not opened until the 1st August 1846. From the 12th August to the 12th September 1846 no progress was made on either side, as the men were required for military duty in camp; but, with the exception of this delay, the driftways were pushed forward without interruption from the dates of commencement, viz. 15th August 1845, and 1st August 1846, until the 23rd of June 1847, on which date an opening was formed, by the two working parties meeting at the distance of 232 feet from the *left* entrance, and 163 feet from the right. The rock in the right portion of the tunnel was generally of a much softer description than that in the left, and the progress was of course proportionally greater. In the *left* tunnel the length of driftway excavated from the 15th August 1845, the date of commencement, to the 1st May 1846, 9½ months, was 109½ feet, or at an average of 11½ feet of progress per month.

In the right tunnel, during the first 9 months, the driftway was excavated to the length of 150 feet, or at the average rate of 16⅔ feet per month.

In the tunnel through Ras-el-Girreff the workmen had to wait a long time, after the mines were fired, before the smoke cleared away sufficiently to enable them to re-enter the shaft, and continue the work. This evil could have been obviated, in a great measure, if there had been a ventilating apparatus.

The number of privates, sappers and miners, employed in the preliminary scarping of the left tunnel, was 2,329.

The number of pounds of powder expended was 1,074.

The preliminary scarping and excavation in the right tunnel was executed by miners and biggaries : the exact number of men cannot be ascertained, nor can the expenditure of powder, but as the soil was of a very soft description, it is not probable that it exceeded 1,000 lbs.

29,144 privates, sappers and miners, were employed in excavating the tunnel, the content of which is 56,293 cubic feet (not allowing for irregularities), and 14,020 lbs. of powder (as near as can be ascertained) were expended; consequently, the average amount excavated by each man was nearly, but not quite, 2 cubic feet; and 4 cubic feet was the amount excavated for every pound of powder expended.

For dressing off the sides of the tunnel with hammers and chisels, 194 bildars, 463 stone-cutters, and 812 privates of sappers, or in all 1,469 men, were employed in dressing a surface of $32 \times 393 = 12{,}576$ square feet, which gives an average per man of $8\frac{1}{2}$ square feet.

The expense of excavating the tunnel was very much greater in proportion than the preliminary scarping; as, from the driftway being so confined, a large quantity of powder is required to produce small effects; for, if the rock be hard, it is impossible to bore holes of greater depth than from 1 to $1\frac{1}{2}$ feet; and the resistance offered by the tamping is so slight, that the charges in many instances have to be repeated several times before any effect can be produced. A great quantity of powder was expended in removing the projecting portions of rock from the sides, floors, and roof of the tunnel: when this could not be effected with hammers, chisels, &c., small charges were applied; but from their being so very numerous, the expenditure of powder, as well as labour, in this operation, formed a considerable item; also the conveying of the soil from the interior of the tunnel was a laborious operation.

The excavation of the driftway was the most tedious por-

tion of the work, but it formed comparatively a small item of the expense, the quantity of soil excavated in forming it being about one-tenth of the whole cubical content of the tunnel. It would have been desirable to have had the tunnel cleared out to its full size, nearly simultaneously with the driftway, or at all events to within a few feet of its inner end. Only a small party was at work for many months after the commencement of the tunnel, the consequence of which was that the progress in clearing the tunnel was not commensurate with the advance of the driftway; and although a larger working party was afterwards employed, they were not able to keep up with the men in the driftway. The evils resulting from a great length of driftway are excessive heat, and the delay caused when the mines are fired, a considerable time elapsing before the smoke clears away.

Note of the Expense of the Tunnel, by Captain W. S. Suart.

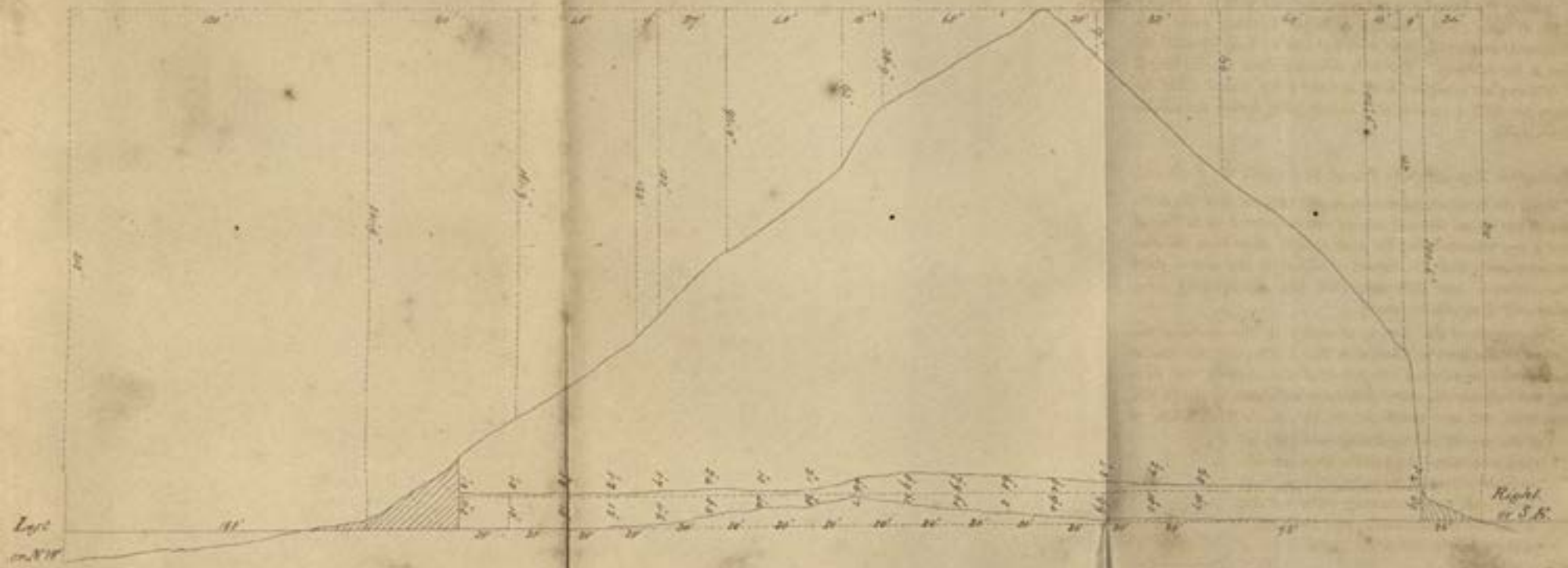
From the longitudinal section it will be seen that the driftway of the tunnel was not carried out horizontal (I believe at first it was intended that the road should slope from the centre outwards); that the tunnel is higher in the centre than was intended; and that more rock had consequently been excavated than was necessary.

The expense of the tunnel, as shown in the books of the Executive Engineer's Office, was Rs. 7,526; but this sum is exclusive of the value of the labour of the sappers and miners; but includes the value of the powder, which, as 16,094 lbs. were used, will, at 5 annas per lb., be ..... Rs. 5,029 6

And the pay of the workmen belonging to the Executive Engineer's Department, with the value of the cotton thread, baskets, coal, steel, drinking water on the works for the sappers, in fact everything paid for by the Executive Engineer 2,496 10

Rs. 7,526 0

Section of the Hill of Ras el Gerify shewing a Longitudinal section of the Tunnel as it was on 26th July 1847.



Scale 50 Feet to an Inch.

Scale 10 Feet to an Inch.

entrance complete

19 feet from entrance

100 feet from entrance

Cross Sections of Tunnel from N.W.

110 feet from entrance

116 feet from entrance

120 feet from entrance

at 130 feet from entrance

at 135 feet from entrance

at 116 feet from entrance

Cross Sections of Tunnel from S.E.

entrance

at 18 feet from entrance

at 36 feet from entrance

at 52 feet from entrance

These Sections taken 11th November 1826.

Drift way at N.W. commenced 15th August 1825.

Do at S.E. 1st August 1826

The Tunnel altogether completed in 1827.

Fig No 1 is also the Section of the Tunnel as originally designed by the Special Committee Lt Colo Grant of the Engrs, & Lt Colo Jacob of the Artillery.

To the above must be added—

The working pay* for 31,473 sappers and miners, at Rs. 7-8-8 per 100	Rs.	2,374 0
And the pay and allowances,† also for the same number, at Rs. 53-9-4 per 100....		16,864 0
The total cost of the tunnel may therefore be considered to have been.....	Rs.	26,764 0

W. S. SUART, Captain,
Commanding Engineer, Aden.

* The working pay to the sappers is of course part of the cost of the tunnel, and a rate per day for it has been thus formed :—

1 Subedar, 5 annas	Rs.	0 5	0
1 Jemadar, 4 annas		0 4	0
4 Havildars, 2 annas each		0 8	0
8 Naiques, 1½ ditto		0 12	0
100 Privates, 11 pies each		5 11	8
Cost of working pay per 100 privates, sappers and miners	Rs.	7 8	8

† It may be a question (as the sappers only work just three-fourths of the time of the labourers of the department) whether the full pay of the native commissioned and non-commissioned officers, or even of the privates, should be charged to the work, leaving nothing to pay for the soldier. I have, however, considered, that as soldiers with very efficient supervision, they should in 7½ hours do as much as workmen in 10 hours; and in the rate used above have taken all the pay, but for only the number of privates absolutely present, and the proportion of native commissioned and non-commissioned due to that number; leaving the Sundays, holidays, the men on guard, &c. to be charged to the Military department. The details of the rate will thus be for a month of 30 days :—

No.		Pay.			Batta.			Value of Rations.			Total Pay to each.			Total.		
		Rs.	*a.*	*p.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*
1	Subedar	42	0	0	15	0	0	3	6	3	58	6	3	58	6	3
1	Jemadar	24	8	0	7	8	0	3	6	3	35	6	3	35	6	3
4	Havildars ..... each	14	0	0	5	0	0	3	6	3	22	6	3	89	9	0
6	Naiques..... ,,	12	0	0	5	0	0	3	6	3	20	6	3	163	2	0
100	Privates..... ,,	8	0	0	1	8	0	3	6	3	12	14	3	1209	4	4
1	Smith*	10	0	0	3	8	0	2	6	9	15	14	9	15	14	9
1	Hammerman	7	8	0	3	0	0	2	6	9	12	14	9	12	14	9
1	Bellows Boy	2	8	0	3	0	0	2	6	9	7	14	9	7	14	9
	Pay, &c. for a month of 30 days													1592	8	1
	Pay, &c. for a single day													53	1	4
	Add water supplied to sappers in their lines.....													0	8	0
	The total expense per day of a working party of sappers of 100 privates, with their superintending native officer, &c.													53	9	4

* No carpenters' work in tunnel.

No. 222 of 1853.

Military Department.

To the Commanding Engineer,

Aden.

Executive Engineer's Office, Aden, 24th March 1853.

Sir,

I have the honor to acknowledge the receipt of your Memorandum No. 3, of 3rd January last, transmitting copy of Military Board's letter No. 12565 of 1852; and with reference to the latter, I propose briefly to notice the subject of blasting to form the scarp of the defensive position now in progress of construction here.

2. I fear, however, that any details I am able to afford will not be of any very general interest; for it must be borne in mind, that excavation by blasting, as practised here, has not for its sole object the detaching of the largest quantity of material, as in the case of quarrying for stone, but the cutting away of the hill side to a constant and regular figure: rates, therefore, obtained from the work under notice, must be expected to be higher than those that would probably be found sufficient for removing rock in a quarry for building or other purposes.

3. The line, I must premise, runs along the crest of a steep range of hills, and the scarp is excavated to a uniform height of 30 feet, and to a batter of 1 in 8, the side of the hill having an average angle of depression of about 35 degrees; the mass to be removed has, consequently, an average section in the form of a 49 degree sector of a circle of 30 feet radius; and in cutting away the rock to such a figure it is apparent that the same attention to the positions of the blast, the lines of least resistance, depths of the hole, &c. as would be practicable and indispensable in a quarry, cannot be given. But though the rates obtained from the work are, perhaps, higher than would

be necessary, were the removal of a given quantity of material alone the object, yet really valuable data as to tasking miners is available.

4. The miners work either singly or in pairs, with the single or double bar—the former weighing from 30 to 36 lbs., with a cutting edge of about 2½ to 2 inches, and a length of about 6 or 6½ feet; the latter weighing from 20 to 25 lbs., with a cutting edge of about 1¼ to 1½ inch, and a length of about 4¾ to 5 feet. The double bar is the tool in most general use, the single bar being only necessary for trimming off the face of the excavation, and for removing projections and small masses of stone, in situations where it would be inconvenient to employ the larger tool.

5. The positions for the blasts are selected by the Overseers, Maistries, and a class of higher paid miners called Butteewallas (or men who attend to the train and firing), but in a confined ditch-like excavation it is apparent that much attention to this point is not practicable, and that all that can be done is to place the blasts at regular intervals, and to endeavour so to fire them that the explosion of one line shall leave a favourable line of least resistance for those in the next row, or, in other words, to work as much as possible along an edge.

6. The miners are of different classes, and on different rates of pay, and are tasked in proportion; but, to prevent confusion, I shall only notice the first class, or Rs. 15 men, who would probably be considered in India as worth Rs. 10 per mensem. A pair of miners with a double bar will do from 8 to 24 running feet as a daily task, according to the nature and texture of the rock worked through, the working time being taken at ten hours per diem, and one man with a single bar will do half that quantity. Table No. 1 shows the tasks in different kinds of rock. The holes used have all been of the same average depth of between 3 and 4 feet, nothing under the former depth being admitted or counted in the day's work, except under special circumstances.

7. The waste of steel in repointing and tempering and sharpening the bars is about as follows for rock of an average degree of hardness:—for every 178 running feet of rock bored 1 lb. of steel will be expended.

8. The charge varies of course with the depth of the holes, and the nature of the rock in which they are bored. For the softer description of stuff, and those of a cellular cindery nature, in which cracks, hollows, &c. are numerous, as well as in seams and masses of volcanic indurated mud, which, though not exactly of the nature of rock, are still too tough and hard to be touched with the pick, a larger charge has been found necessary than is requisite in the more compact and harder kinds. In the first instance, the rate for calculating the quantity has been taken at 4 ozs. to the running foot, and this has been found to answer very well, all attempts to decrease the charge giving unfavourable results; for the harder rocks 2 to 2½ ozs. per running foot have been found sufficient: between these two quantities, viz. 2 and 4 ozs. per running foot, as minimum and maximum, all the charges have ranged in different degrees, proportioned to the varying nature of the soil worked through.

9. The powder used is the ordnance cannon powder, supplied from the Government arsenal, and it appears well adapted for blasting purposes. Some native-made powder, obtained from the Sultan of Lahedge, was used during one period, but it was of inferior quality, and the results given by it are not worthy of notice, except as, I think, going towards refuting a commonly received opinion, that slow inferior powder is better adapted for blasting purposes than that of greater strength and quickness. It is difficult to comprehend on what line of reasoning this opinion has been founded, and I am myself inclined to consider it a fallacious one, and that, in blasting, as well as in every other operation in which that article is employed, the better the powder the better the results obtained, provided the charges are properly proportioned.

10. The tamping is performed in the usual manner, the

material used being a kind of volcanic earth or mud of a homogenous texture, free from stones, and not unlike a very hard description of brick. This is found in masses and seams about the hills, and is apparently the volcanic mud of ancient eruptions, partially calcined, especially near its surface, by the contact of subsequent streams of burning lava which have passed over it. It forms a very strong and safe tamping, and, considering the extent of the operations that have been carried on (the daily average of powder blown away in blasts being at one time 500 lbs.), accidents from premature explosions have been comparatively rare.

11. The strength of the tamping material is so great that it has been found impracticable to use copper or brass priming rods, neither of these metals being sufficiently strong to resist the torsion of turning the rod during the tamping. The miners themselves, with good reason, object to their use: they twist and break almost immediately; and it has been found necessary to substitute iron ones.

12. Dry sand tamping was tried by the men of the sappers and miners, but discontinued as ineffectual. I have great doubts of the efficiency of this description of tamping under any circumstances, except where the line of least resistance is disproportionately small with reference to the length of hole tampered; but here, with shallow blasts, it was found a complete failure.

13. The train for firing the blasts is a quick-match, composed of cotton thread steeped in gunpowder and water, and afterwards dried in the sun. The proportion of material to compose, and mode of construction, are as follows:—1 lb. of cotton thread, cut into lengths of about 3 feet, and twisted into loose strands, composed of nine or ten threads, is steeped in a mixture composed of 2 lbs. of powder and water, and is then dried for use: this quantity will give about 166 running feet of fuze, which will burn at the rate of about 15 feet per minute, and is not easily put out by the falling stones and rubbish of the blasts as they explode in succession. It is necessary to

fix the train firmly into the top part of the tamping of each hole, so that the jerk of the adjoining blast going off may not disengage it, and so cut off the communication. It is also necessary to provide against this accident still further by connecting each blast with several others, so that if the train is cut off at one point by a falling stone, or in any other way, the ignition of the blast may still be effected from another quarter. When these precautions are attended to, misfires are not of very frequent occurrence, although the train is sometimes apparently completely buried in the *débris* of the mines which have first exploded, and the train has, as it were, to burn almost under ground.

14. Table No. 2 shows the classification and distribution of the labour, and the number of the different denominations of workmen, &c. per each 100 miners, taken as a standard.

15. Table No. 3 gives an average detailed rate for excavating in rock, obtained from the work scarping the Munsoorie height, from the accounts of which all the data here given have been obtained.

16. The practice of using large chamber mines in excavating to form scarp has been abandoned, owing to the difficulty of regulating their effects; it having, I believe, been found, on the explosion of a large charge, as difficult to break up for removal the large masses thrown down, and reduce the excavation to the required figure, as it would have been to execute, in the first instance, the entire portion of scarp by blasting alone: added to this, the difficulty, expense, and delay, in cutting shafts, galleries, and chambers in solid rock, is very great, and these considerations have led to the disuse of large mines.

17. In the Munsoorie scarp only one large double mine was sprung, which was intended to blow off the point of a very marked and projecting spur, round which the scarp line had to be carried: the distribution of the layers of volcanic matter which composed it was such as to lead to the belief that the rock could at once be blown out very nearly to the required

figure; and though I have to record a partial failure in this particular, yet I think the experiment was not without its results, as demonstrating the facility of simultaneously exploding two, or even more charges, when placed at no very great intervals from a common centre.

18. The method employed of firing the charges was very simple, and as I have seen it nowhere noticed, I will venture to describe it. The galleries, as usual, branched off from the bottom of the shaft, and terminated in the chambers. The boxes containing the two charges (300 lbs. each) being placed in position, the ends of two stout tin tubes, cased in and strengthened by wooden battens, were introduced, one into the centre of each charge, the other ends meeting in a small box placed midway between the chambers at the bottom of the shaft. In this box was placed an exploding charge of 1½ lb. of powder, into which was inserted the hose leading up through the tamping in the usual manner. The exploding charge, being fired by the hose, acted through the tubes like the discharge of a couple of muskets into the chambers, and the mines went off quite simultaneously. In this instance the distance between the two chambers was only 12 feet, but I have tried the same arrangement, experimentally, at greater, and also at irregular intervals, with success: up to certain limits it might always, I think, be employed with confidence; but for long distances strong piping would probably be required, to resist the force of the large exploding charge that would be necessary.

19. I am not aware that I can say anything more of interest on this subject: perhaps I have already dilated more than may be considered necessary, for the subject of blasting and quarrying in rock is so well known, and the mode of operation so familiar, that it seems mere repetition to dwell on either. I trust, however, the table of miners' tasks given may be found useful for guidance elsewhere. I can only add that I believe we obtain here a fair amount of labour: the system of fining is very strict, and rigidly attended to, so that the tasks we

exact may be taken with confidence as nearly the utmost that men can be expected to perform for a continuance.

I have the honor to be,

Sir,

Your most obedient Servant,

M. K. KENNEDY, Lieutenant,

Executive Engineer, Aden.

TABLE No. 1.

Statement of Miners' Tasks.

Nature of Rock.	A pair of 1st Class Miners will perform as a Daily Task	A single 1st Class Miner will perform as a Daily Task	Charge per Running Foot of Hole.	Remarks.
	ft.	ft.	oz.	
Trap rock of a porphyritic character, very hard.	8	4	2	A good building stone.
Basaltic lava, the crystals composing the paste of which are so minute as hardly to be separately distinguished, also very hard.	8	4	2	This rock is about the same density as the blue trap of the Deccan. It is very brittle, and difficult to work; and, though extremely hard when first excavated, is unfit for building purposes, as the exposed surfaces soon decompose.
Basaltic lava, very like the above in appearance, but not so hard.	11	5	2½	Quite unfit for building.
Basaltic lava, similar to the above in appearance, but still softer, and less brittle.	13	6½	2½	Ditto ditto.
Igneous rock of a cindery description, cellular, and full of holes and cracks.	18	9	4	This, owing to the fissures it contains, is very difficult to get through, some of the blasts producing very little effect.
Indurated volcanic mud, containing stones, and streaks of harder matter.	20	10	4	
Ditto ditto ditto, of an uniform texture.	24	12	4	

There are of course many intermediate descriptions of stuff: those above noticed I have selected as marked specimens of each class. The first and second might be taken as of about the same hardness and density as Deccan trap rock, and a standard of comparison for tasks in India thus instituted.

TABLE No. 2.

Table showing the Proportion of the different descriptions of Labour, &c. employed on the Blasting Operation to form Scarp, per 100 *Miners.*

Miners.	Tampers.	Buttee-wallas, or Train Men.	Marwallas, or Men with Crowbars, to remove loosened Rock.	Biggaries, to remove Rock, and clear Excavations.	Average Running Feet of Rock bored.	Average Quantity of Powder exploded.	Average Running Feet of Fuze required.	Average Cubic Feet of Rock excavated and removed.	Remarks.
						lbs.			
100	3·871	0·799	16·854	57·93	689¾	150·39	620	2840	

TABLE No. 3.

Detailed Rate for Excavating, per 100 *Cubic Feet.*

No. or Quantity.	Description.	Rate.	Per	Amount.	Total.
	LABOUR.	*Rs. a. p.*		*Rs. a. p.*	*Rs. a. p.*
4·845	Miners	12 11 6	Month.	2 0 10·383	
1·052	Marwallas	8 0 0	,,	0 4 5·862	
·084	Smiths	18 14 9	,,	0 0 10·172	
·057	Hammermen	9 0 4½	,,	0 0 3·291	
2·071	Biggaries	7 0 0	,,	0 7 8·78	
	Superintendence	....	,,	0 0 11·178	
				2 15 2·256	
	Deduct fines, &c			0 10 11·555	
	Total amount of labour				2 4 2·701
	MATERIALS.				
·232	Pounds Cotton Thread	0 4 9	lb.	0 1 1·214	
·018	Pounds Swedish Iron	2 0 9	Md.	0 0 0·262	
·009	Pounds English Iron	1 12 0½	,,	0 0 0·108	
.072	Pounds Bar Steel Blister.	0 2 1 1/6	lb.	0 0 1·812	
6·439	Pounds Powder	0 5 0	,,	2 0 2·340	
·077	Cwt. Coal	23 8 3½	Ton.	0 1 5·384	
	Sundries	....	,,	0 1 3·301	
	Water	....	,,	0 1 8·193	
	Total amount of materials				2 5 10·614
	Total for 100 cubic feet of rock excavated				4 10 1·315

M. K. KENNEDY, Lieutenant,
Executive Engineer, Aden.

Comparative Statement of Expenditure and Establishment in the Executive Engineer's Department, Aden, for the Year 1851-52, *called for in Military Board's Circular No.* 11464, *of* 26*th October* 1852.

		Rs.	*a.*	*p.*
Executive Engineer	Staff Salary	6,000	0	0
	Extra batta	703	1	8
	Regimental allowances, less net pay	1,617	4	6
Assistant Executive Engineer	Staff salary	640	9	6
	Extra batta	111	1	6
	Regimental allowances, less net pay	154	4	11
Permanent establishment		10,433	10	7
		19,660	0	8
Other expenditure		1,60,196	1	8
Gross expenditure		1,79,856	2	4
Per-centage of staff salary, extra batta, regimental allowances, less net pay, and permanent establishment, on gross expenditure		10·903		

c

M. K. KENNEDY, Lieutenant,
Executive Engineer, Aden.

Executive Engineer's Office,
Aden, 25*th January* 1853.

No. 1549 of 1853.

MILITARY DEPARTMENT.

To the SECRETARY MILITARY BOARD,

Bombay.

Superintending Engineer's Office, Camp Indee, 12th May 1853.

Sir,

I have the honor to transmit statement of the expenditure in the Public Works Department, under the Superintending Engineer Southern Provinces, for the year 1851-52, ending 30th April 1852, exhibiting the amount spent for repairs, annual repairs, and new works in the Military and Civil Departments, separately, with the charge for superintendence, as directed in your Circular 11464, of 26th October last.

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POONA.				Military.			Civil.		
				Rs.	*a.*	*p.*	*Rs.*	*a.*	*p.*
Repairs				9,410	8	0	5,843	7	2
Annual repairs				16,043	12	1	6,645	1	9
New works				33,980	13	9	4,711	9	3
				59,435	1	10	17,200	2	2
Staff Pay.							59,435	1	10
Captain Hebbert	Rs.	3,983	13 11				76,635	4	0
„ Berthon		2,016	2 1						
				6,000	0	0			

POONA *(continued)*.

				Military.	Civil.
				Rs. a. p.	*Rs. a. p.*
Extra Batta.					
Captain Hebbert	Rs.	727 8 10			
„ Berthon		368 3 2			
			1,095 12 0		
Regimental Allowance, less Nett Pay.					
Captain Hebbert	Rs.	1,618 8 0			
„ Berthon		809 4 0			
			2,427 12 0		
			9,523 8 0		
Permanent establishment		.....	11,641 9 7	.....	21,165 1 7
Per-centage		21·641			97,800 5 7

AHMEDNUGGUR.

	Military.	Civil.
	Rs. a. p.	*Rs. a. p.*
Repairs	2,165 15 9	4,208 11 5
Annual repairs	3,539 0 7	1,421 6 1
New works	1,327 2 11	5,048 11 5
	7,032 3 3	10,678 12 11
		7,032 3 3
		17,711 0 2

Staff Salary.

Major Kilner, half staff		625	0 0
Lieutenant Annesly		1,379	9 2
,, Nasmyth		306	7 3
Captain Hebbert		580	10 3
Lieutenant Beamish		108	5 4
		3,000	0 0

Extra Batta.

Lieutenant Annesly	Rs. 442 15 0		
,, Nasmyth	75 1 9		
Captain Hebbert	212 1 3		
Lieutenant Beamish	26 6 0		
		756	8 0

Regimental Allowance, less Nett Pay.

Lieutenant Annesly		1,083	7 9
,, Nasmyth		215	5 0
Captain Hebbert		606	15 0
Lieutenant Beamish		53	13 3
		1,959	9 0
		5,716	1 0
Permanent establishment		2,383	15 0
			8,100 0 0
Per-centage	31·382		25,811 0 2

N. B.—Major Kilner was employed on detached duty, though his half staff salary was drawn at Ahmednuggur.

Belgaum.

		Military.			Civil.		
		Rs.	*a.*	*p.*	*Rs.*	*a.*	*p.*
Repairs		4,734	3	11	2,758	6	11
Annual repairs		3,101	8	10	20,829	10	1
New works		5,151	10	8	33,447	10	3
		12,987	7	5	57,035	11	3
					12,987	7	5
Captain North.							
Staff salary	Rs. 4,200 0 0				70,023	2	8
Extra batta	730 8 0						
Regimental allowance, less nett pay	1,618 8 0						
Permanent establishment	11,521 9 0						
		.....			18,070	9	0
Per-centage 20·513					88,093	11	8

Dharwar.

		Military.			Civil.		
		Rs.	*a.*	*p.*	*Rs.*	*a.*	*p.*
Repairs		56	7	11	12,121	7	2
Annual repairs		27	11	7	5,039	14	1
New works		19	0	0	12,549	6	2
		103	3	6	29,710	11	5
					103	3	6
Staff Salary.							
Captain Cruickshank	Rs. 3,528 3 7				29,813	14	11
Lieutenant Wood	671 12 5						
	4,200 0 0						

Extra Batta.

Captain Cruickshank	Rs.	913	2	0			
Lieutenant Wood		121	12	0			
					1,034	14	0

Regimental Allowance, less Nett Pay.

Captain Cruickshank	Rs.	3,080	13	0			
Lieutenant Wood		391	8	0			
					3,472	5	0
					8,707	3	0
Establishment		.....			11,466	15	5
					.....		20,174 2 5
Per-centage	40·358						49,988 1 4

KOLAPOOR.

	Military. Rs. a. p.	Civil. Rs. a. p.
Repairs	.....	.....
Annual repairs	1,415 7 3	99 0 0
New works	.....	484 4 3
	1,415 7 3	583 4 3
		1,415 7 3
		1,998 11 6
Superintending allowances	.....	622 13 0
Per-centage 23·757		2,621 8 6

SHOLAPOOR.	Military.			Civil.		
	Rs.	*a.*	*p.*	*Rs.*	*a.*	*p.*
Repairs	468	0	0	1,763	0	3
Annual repairs	1,040	1	8	125	10	0
New works	611	0	0	.....		
	2,119	1	8	1,888	10	3
				2,119	1	8
				4,007	11	11
Superintending allowances	.....			852	0	0
				4,859	11	11
Per-centage ..... 17·531						

KHANDESH.	Military.			Civil.		
	Rs.	*a.*	*p.*	*Rs.*	*a.*	*p.*
Repairs	124	4	0	22,584	12	1
Annual repairs	442	4	11	12,234	0	6
New works	261	8	2	40,756	8	2
	828	1	1	75,575	4	9
				828	1	1
				76,403	5	10

Staff Pay.

Lieutenant Bell	Rs.	5,400	0 0
,, Jones		747	11 11
Captain Adams		2,260	0 0
			8,407 11 11

Extra Batta.

Lieutenant Bell	Rs.	730	8 0
,, Jones		182	10 0
Captain Adams		1,004	7 0
			1,917 9 0

Regimental Allowance, less Nett Pay.

Lieutenant Bell	Rs.	1,618	8	0				
,, Jones		404	10	0				
Captain Adams		2,225	7	0				
					4,248	9	0	
Permanent Establishment		.....			12,969	8	8	
							.....	27,543 6 7
Per-centage	26·401							1,03,946 12 5

MALLIGAUM (under Staff Officer).	Military. Rs. a. p.	Civil. Rs. a. p.
Rapairs	501 11 3	.....
Annual repairs	509 0 0	.....
New works	.....	.....
	1,010 11 3	.....
		1,010 11 3
Allowance for superintendence	.....	108 0 0
Per-centage 9·654		1,118 11 3

SATTARA.	Military. Rs. a. p.	Civil. Rs. a. p.
Repairs	125 14 2	2,514 3 7
Annual repairs	1,859 0 0	27,821 0 0
New works	.....	1,22,386 5 2
	1,984 14 2	1,52,721 8 9
		1,984 14 2
		1,54,706 6 11

SATTARA *(continued)*.

		Military.	Civil.
		Rs. a. p.	*Rs. a. p.*
Staff salary to Captain Hart	Rs. 9,960 0 0		
Travelling allowance	2,410 0 0		
Extra batta	Included in foregoing staff salary.		
Regimental allowance, less nett pay			
Staff salary to Mr. Smith	Rs. 3,600 0 0		
Travelling allowance	108 0 0		
Staff salary to Mr. West	4,687 5 4		
Tentage	890 0 0		
Staff salary to Ensign Elphinstone	1,965 8 3		
Extra batta	281 15 1		
Regimental allowance, less nett pay	1,773 12 10		
Establishment	14,884 4 4	.....	40,560 13 10
			1,95,267 4 9
Per-centage	20·772		

ASSEERGHUR.

	Military.	Civil.
	Rs. a. p.	*Rs. a. p.*
Repairs	747 11 4	747 11 4
Allowance to Officer superintending	.....	158 0 0
		905 11 4
Per-centage	17·445	

DAPOOLIE.

	Military.	Civil.
	Rs. a. p.	*Rs. a. p.*
Repairs	588 0 3	92 14 0
Annual repairs	202 0 0	.....
New works	.....	.....
	790 0 3	92 14 0

			790	0 3
			882	14 3
Allowance to Officer superintending			164	8 0
Per-centage	15·705		1,047	6 7

I have the honor to be,
Sir,
Your most obedient Servant,
WALTER SCOTT, Lieutenant Colonel,
Superintending Engineer, Southern Provinces.

Comparative Statement of Expenditure and Establishment for the Year 1851-52.

Staff salary	Rs.	3,600	0	0
Extra batta		730	8	0
Regimental allowances, less nett pay ..		1,618	8	0
Permanent establishment		8,894	12	2
		14,843	12	2
Other expenditure		36,082	12	3
Gross expenditure		50,926	8	5
Per-centage of staff salary, extra batta, regimental allowances, less nett pay, and permanent establishment, on gross expenditure.		29·147		

This amount includes Rs. 791-13-3 batta of Surveyor and Maistry; Rs. 545 office tentage and tent carriage; Rupees 134-6-2 for puggees employed for the protection of public buildings at Kaira and Hursole; and Rs. 120 horse allowance to Serjeant Overseer.

This amount includes Rs. 120 oil allowance for public guards, and Rupees 337-0-7 stationery allowance.

W. R. DICKINSON, Lieutenant,
Executive Engineer, Ahmedabad Division.

Executive Engineer's Office, Ahmedabad,
6*th January* 1853.

Comparative Statement of Expenditure and Establishment for the Year 1851–52.

Staff salary.	2nd Lieut. D. Nasmyth.. Rs.	1,103	3	7	
	Lieut. C. Nasmyth ..	1,296	12	4	
Extra batta.—2nd Lieut. D. Nasmyth ..		251	13	6	The extra batta for Lieutenant C. Nasmyth is drawn in the 4th Troop Horse Artillery abstracts.
Regimental allowances, less nett pay.	2nd Lieut. D. Nasmyth..	593	13	6	Ditto ditto ditto.
Permanent establishment		3,575	10	7	This amount includes Rs. 104-7-4 batta and allowance of Surveyor and Maistry; Rupees 119-5-9 horse allowance to acting Overseer O. Droft; Rupees 47-11-10 horse rent to ditto; and Rupees 90-9-2 for puggees employed for the protection of public buildings on Mount Aboo.
		6,721	5	6	
Other expenditure		20,911	6	0	This amount includes Rs. 120 oil allowance for public guards, and Rs. 148-13-3 for stationery supplied.
Gross expenditure		27,632	11	6	
Per-centage of staff salary, extra batta, regimental allowances, less nett pay, and permanent establishment, on gross expenditure.....	....	24·324			

C. NASMYTH, Lieutenant,
Late Acting Executive Engineer, Deesa Division.

Executive Engineer's Office, Camp near Deesa, 17*th March* 1853.

Comparative Statement of Expenditure and Establishment for the Year 1851-52.

Staff salary	Rs.	220	0	0
Extra batta		.....		
Regimental allowances, less nett pay ..		.....		
Permanent establishment		.....		
		220	0	0
Other expenditure		1,647	7	9
Gross expenditure		1,867	7	9
Per-centage of staff salary, extra batta, regimental allowances, less nett pay, and permanent establishment, on gross expenditure.....		11·780		

This is not in the bills called a staff salary, but is the amount of Rs. 2 per diem drawn by the Major of Brigade, while he is superintending public works.

The Major of Brigade draws this in his other abstracts in the Military Department.

Ditto ditto ditto.

None.

This amount includes Rs. 144 for a writer; Rs. 60 oil allowance for public guards; and Rs. 6-2-4 the cost of stationery.

B. R. POWELL, Captain,
Major of Brigade, in Charge of Public Works.

Rajkote, 20*th March* 1853.

Comparative Statement of Expenditure and Establishment for the Year 1851-52.

Staff salary .. ..Rs.	334 0 0	This is not in the bills called a staff salary, but is the amount of Rs. 2 per diem drawn by the Line Adjutant, while he is superintending public works.
Extra batta	.....	The Line Adjutant draws this in his other abstracts in the Military Department.
Regimental allowances, less nett pay ..	.....	Ditto ditto ditto.
Permanent establishment	.....	None.
	334 0 0	
Other expenditure	3,882 1 10	This amount includes Rs. 132 for a writer; Rs. 60 oil allowance for public guards; and Rs. 17-2-2 the cost of stationery.
Gross expenditure	4,216 1 10	
Per-centage of staff salary, extra batta, regimental allowances, less nett pay, and permanent establishment, on gross expenditure.....	.... 7·922	

R. LAURIE, Lieutenant,
Line Adjutant, in Charge of Public Works, Bhooj.

Bhooj, 5th April 1853.

Comparative Statement of Expenditure and Establishment for the Year 1851-52.

Staff salary.	Lieut. M. Kennedy.....	Rs.	1,260	0	0	
	Captain T. L. Jameson..		1,718	4	4	
	Brevet Major J. Kilner .		501	11	6	
Extra batta.	Lieut. M. Kennedy.....		255	10	9	
	Captain T. L. Jameson..		440	13	1	
	Brevet Major J. Kilner..		198	5	10	
Regimental allowances, less nett pay.	Lieut. M. Kennedy		466	4	9	The regimental allowance to Captain Jameson is drawn in the 29th Regiment's abstract.
	Brevet Major J. Kilner..		442	15	3	
Permanent establishment			8,364	13	5	This amount includes Rs. 332-13-3 for horse allowance to European Overseers; Rs. 3-8-0 passage to ditto; Rupees 371-1-11 for batta and allowances to Surveyors, Writers, Maistry, and Peons, &c.; and Rs. 240 for office rent at Broach.
			13,648	14	11	
Other expenditure			11,371	4	5	This amount includes Rs. 120 oil allowance for public guards; Rs. 312 for stationery allowances; and Rs. 210 passage money.
Gross expenditure			25,020	3	4	
Per-centage of staff salary, extra batta, regimental allowances, less nett pay, and permanent establishment, on gross expenditure		....	54·551			

T. L. JAMESON, Captain,
Acting Executive Engineer, Surat Division.

Executive Engineer's Office, Surat,
28th March 1853.

No. 1784 of 1852.

Public Works. General Department.

To the Secretary to the Military Board,

Bombay.

Sir,

I have the honor to forward the Annual General Report of the proceedings of the Public Works Department in Scinde, during the official year 1851–52.

2. The expenditure from the 1st of May 1851 to the 30th April 1852 in the Military, Civil, and Marine Departments, is as follows:—

Expenditure in the Military, Civil, and Marine Departments of the several Executive Officers in Scinde.

Names of Divisions.	Amount expended on each.	Amount of Superintendence.	Superintending Percentage.
	Rs. a. p.	*Rs. a. p.*	*Rs. a. p.*
Lower Scinde.			
Military Department.			
Repairs	7,986 11 0		
Annual repairs	3,235 1 3		
Barrack Department	2,145 15 7		
New works	1,08,569 7 0		
Total Military Department..	1,21,937 2 10		
Civil Department.			
Repairs	6,218 5 4		
Annual repairs	90 9 4		
New works	74,840 1 11		
Total Civil Department....	81,149 0 7		

Names of Divisions.	Amount expended on each.			Amount of Superintendence.			Superintending Percentage.		
	Rs.	*a.*	*p.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*
LOWER SCINDE *(continued).*									
Marine Department.									
Annual repairs	85	7	9						
New works	285	1	10						
Total Marine Department ..	370	9	7						
Total Military Department ..	1,21,937	2	10						
Total Civil Department	81,149	0	7						
Grand Total..	2,03,456	13	0	18,709	3	11	9	3	1·571
CENTRAL SCINDE.									
Military Department.									
Repairs	6,567	12	7						
Annual repairs	997	13	3						
New works	17,050	9	4						
Total Military Department..	24,616	3	2						
Civil Department.									
Repairs	1,577	13	3						
Annual repairs	2,034	7	6						
New works	4,138	4	6						
Total Civil Department....	7,750	9	3						
Marine Department.									
Repairs	159	3	4						
Total Military Department..	24,616	3	2						
Total Civil Department	7,750	9	3						
Grand Total..	32,525	15	9	15,895	10	8	48	13	11
UPPER SCINDE.									
Military Department.									
Repairs	3,408	3	1						
Annual repairs	592	13	5						
New works	3,131	12	5						
Total Military Department..	7,132	12	11						

Names of Divisions.	Amount expended on each.	Amount of Superintendence.	Superintending Percentage.
	Rs. a. p.	*Rs. a. p.*	*Rs. a. p.*
UPPER SCINDE *(continued)*.			
Civil Department.			
Repairs	3,108 12 1		
Annual repairs	242 4 5		
New works	8,076 4 7		
Total Civil Department..	11,427 5 1		
Marine Department.			
Repairs	424 15 6		
Annual repairs	247 9 7		
Total Marine Department ..	672 9 1		
Total Military Department..	7,132 12 11		
Total Civil Department	11,427 5 1		
Grand Total..	19,232 11 1	8,863 11 6	43 1 10½
Total of expenditure,.	2,55,215 7 10		

3. I annex for publication, should the Military Board think fit, Lieutenant Fife's report on a style of roof introduced by him, which its peculiarity, cheapness, and the general success that has attended the various instances in which it has been tried, induce me to regard as a paper of special interest.

4. Under Lieutenant Fife's superintendence, such roofs have been built for the sum of Rs. 9 per 100 square feet. In Central Scinde it is estimated to cost Rs. 13 ; but, I expect, when the labourers become more accustomed to the work, the rates will nearly correspond. Even Rs. 13, however, is so moderate a rate for a durable roof, that wherever white-ants abound, I consider it well worthy of a trial.

5. Lieutenant Fife's attention was probably attracted to the style of roof by the circular hollow-tiled Syrian roof,

which has, I believe, been largely adopted at Madras, and of which the dome of the ice-house in Bombay is a specimen; but the great superiority of his invention consists in the peculiar form of the hollow tiles, from which a vault can be built with perfect safety (as yet 22 feet span is the largest) without any centering whatever.

I have the honour to be,

Sir,

Your obedient Servant,

H. B. TURNER, Major,

Superintending Engineer, Scinde.

Kurrachee, 1st September 1852.

PUBLIC WORKS. GENERAL DEPARTMENT.

To the SUPERINTENDING ENGINEER IN SCINDE,

Kurrachee.

SIR,

I have the honour to acknowledge the receipt of your letter No. 1790, of the 5th instant, calling on me to report the result of the experiments in vaulting roofs on the plan lately proposed by me.

2. The first experiment made was that mentioned in my first communication on this subject. After succeeding in making the voussoirs, I constructed about 7 feet of the crown of an arch of 15 feet span, to ascertain whether the method was practicable. The result was most satisfactory. It was evident, that beyond the difficulties a workman experiences in constructing anything new to him, nothing existed against the practicability of the plan.

3. The next thing to ascertain was whether the hollow voussoirs would really bear the great strain to which theoretically they were equal. The small vault mentioned in the preceding paragraph was turned on the ground in one of the verandahs of my bungalow, and during the months it remained there it was continually crossed and recrossed by myself and my office establishment. It did not suffer the slightest injury. But to ascertain what the result would be in the case of a complete vault, as it would be constructed in roofing, I made another experiment. I constructed a semi-circular vault (Figs. 1 and 2) of 15 feet span, springing from the ground. The haunches were carried up 5 feet with sun-dried bricks and mud, and the remainder vaulted in with the voussoirs. As this was being done, I placed three rods (*a*, *a*, *a*,) directly under the crown of the vault, and almost touching it, to see what

amount of settlement would take place. This completed, I commenced loading the vault with bricks. They were piled on without any bond or cement, till they were 1½ foot deep on the light portion of the vault, and rather more on the haunches. During this process I carefully watched to see what amount of settlement in the vault would take place. When the loading was about 1 foot thick, I observed that the vault had settled about half an inch. I believe that even this trifling settlement was principally due to the haunches, which, being constructed of brick, and having, therefore, a greater number of joints, were more liable to settlement than the other portion of the vault. I did not observe any further settlement when the load was increased. I allowed the vault to remain loaded for two or three days, after which I took it to pieces, to see whether the voussoirs had sustained any injury. Of the 700 voussoirs which formed the vault, only two were broken, and of these one was misshaped (having been hastily removed from the mould), and the other had not been properly burnt. Among those which had borne this severe test there were many so thin as not to weigh more than 3½ lbs., the solid voussoir weighing 15 lbs. The load borne by the light upper portion of the vault amounted to 13 tons.

4. The practicability of this plan, and its trustworthiness, being thus proved, I made a third experiment, to see what thickness of wall would be sufficient to bear the thrust of a vault of this description. With this view I constructed a vault (Figs. 3, 4, and 5,) of 12 feet span, on walls 1½ foot thick, and 9½ feet high, the haunches being carried up 4 feet with brick. The side walls had two arched openings of 4 feet; the end walls had each an arched opening of 10 feet, the wall above the crown of each being carried up to the requisite height in open brick-work, as shown in Fig. 5. With the exception of the arches over the end openings, which were turned with burnt brick, the whole of the walls were constructed with sun-dried brick and mud. Thus constructed, the side walls, which had to bear the thrust of the vault, were but little tied together by

the end walls, and the latter had little substance to prevent their being thrust outwards by any longitudinal thrust the vault might exert in leaning against them. While the vault was being constructed, I carefully watched the walls, to see whether any movement took place. None, however, occurred. I allowed this vault to stand about six weeks. On taking it down, I found the voussoirs uninjured.

5. It is evident, from the result of the last experiment, that in ordinary spans we have nothing to fear from the thrust of the vault. We seldom make verandahs 12 feet wide. The verandah vault, therefore, may be considered to act as a flying buttress to the main vault, supposing there were anything to fear from the thrust of the latter.

6. I had it in view to make further experiments with flat sweep vaults, and also with larger spans. I, however, had no leisure before leaving Shikarpore.

7. The buildings at Shikarpore are being constructed on this plan—the travellers' bungalow lately sanctioned, and a barrack and quarter guard for the Upper Scinde Police. The first of these was commenced very lately, and the vaulting had not been executed when I left Shikarpore. The main vault is to be 16 feet in span, and will rise 5 feet 4 inches, walls 2 feet thick, of sun-dried brick. The verandah vaults are to be 8½ feet in span, and will rise 2 feet 10 inches; walls 1½ foot thick. The walls of the quarter guard only have been constructed. The vaults are to be the same as those of the travellers' bungalow. The main and verandah walls are also respectively 2 feet and 1½ foot thick. The barrack is nearly completed. It consists of two vaults, 240 feet in length, with binding arches about every 30 feet, except in the centre, where there is one interval of 50 feet. The vaults are semi-circular, and of 15 and 9 feet span. It was originally intended that this last building should be domed, and, with this view, its walls had been commenced 5 feet in thickness. There would have been fourteen domes of 15 feet span on the main walls, and the building would have been divided

into as many compartments by thirteen massive binding arches. When, at the suggestion of the Commissioner, Captain Stanley consented to have this building constructed on my plan, I carried the walls up about one-half the thickness that had been determined on, omitted more than half the binding arches, and carried the remainder up to within a foot of the vault; thus not only reducing the walling and arch-work by about one-half, but also obtaining better ventilation, by having the building open from end to end,—an advantage but imperfectly attained in the original plan. This building is a very good example of the advantages of the new plan.

8. The experiments made by me do not furnish data for calculating the exact cost of each item of work, as the workmen employed had to be taught at the same time; and it was, moreover, requisite occasionally to work with great caution. The police barrack, also, is almost useless for this purpose, because it was partly done by convict labour. From this work, however, I have ascertained that the voussoir vaulting is done more rapidly than brick vaulting, *i. e.* a workman can do a greater day's work; and that from the small number of voussoirs required, and the small quantity of cement used, fewer labourers to assist the masons are necessary. As the voussoirs in superficial measurement do not cost more than common bricks, the plan is, therefore, less costly than the brick vault, irrespective of the enormous saving in the walls. I believe that a rate of Rs. 8 or 9 per 100 square feet will cover the expense, supposing the exterior and interior plaster to be of mud and bhoosa. If chunam plaster for the exterior is used, an addition to the above rate must of course be made. The brick-work in the haunches scarcely differs from common walling.

9. The accompanying papers, prepared in a convenient form, explain the method of making the voussoirs, and the manner in which they are used. It will, probably, be remarked, that the plan is troublesome, and, at first, tedious; but I think

that if the method of cutting and seasoning timber, and the time required for the latter process, with the description of the manner of sawing it up, forming it into trusses, and finally constructing the roof, were similarly detailed, the result would be in favour of vaulting. It frequently happens, in carrying on public works in this country, where there is no regular market for timber, that buildings are delayed, or have to be constructed in a faulty manner, from want of seasoned timber. How great, then, is the advantage of a plan which can be in full operation in a few months, and how convenient to be enabled to manufacture the material on the spot, and under your immediate superintendence. These remarks are equally applicable to the Syrian roof described in the Corps' Papers by Major Underwood, of the Madras Engineers, and which construction suggested mine.

I have the honour to be,
Sir,
Your most obedient Servant,
J. G. FIFE, Lieutenant,
Executive Engineer, Upper Scinde.

Kipree, West Bank of Nara, 24th December 1851.

Description of the Method of making Hollow Hexagonal Voussoirs, and Vaulting Roofs with them.

To form the moulds, a solid wooden voussoir is first made, in the following manner :—a piece of wood about 15 inches in length, and 9 inches in diameter, is shaped into a tolerably accurate cylinder. Its ends are then sloped off, till it becomes oblique, as shown in Fig 1. Hexagons are then inscribed in circles of about 8 inches diameter, at each end, (Figs. 2 and 3,) care being taken, by previously drawing a straight line from top to bottom of the cylinder, to make the hexagons

parallel. From the sides of the hexagon at the bottom half an inch, or whatever may be required, is cut off (Fig. 3). The superflous wood is then pared away, leaving the solid voussoir, as shown in Figs. 4 and 5, a piece of wood being inserted at the broad end as a handle.

Some common earthen koondas (Fig. 6) are then made, in the ordinary manner, having their tops sloped at the same angle as the voussoir, but accuracy in this case is not necessary. When the koondas are dry, they are sawn in two; after this they may be burnt. They may also be made of wood; but the earthen ones only cost a few annas each, and are not liable to warp.

To make the moulds, clay mixed the day previous, and containing rice bhoosa, to prevent cracking, is beaten into flat cakes with the hand, and placed in the half koondas, and well pressed against the sides and bottom with the hand. The two pieces of koonda are then bound together with a piece of rope. An iron rod something less than a quarter of an inch in diameter is then inserted into a hole at the centre of the bottom of the koonda. Next, the wooden voussoir, which has a hole bored through it for the reception of the rod, is forced into the koonda, pressing the clay against the sides and bottom. This is repeated four or five times, care being taken to keep the voussoir wet, to prevent it adhering to the clay. If there appears to be too little clay in the koonda, from the cakes having been too thin, more can be added, until the wooden voussoir, by compressing it, forms a mould as accurate as itself. The voussoir ought to be carefully withdrawn from the mould, otherwise the mouth will be spoiled.

The mould ought not to be removed from the koonda for four or five days, as, the mass of clay being great, it is liable to crack; it ought, moreover, to be kept in the shade, and, while drying, any cracks that may appear ought to be stopped with moist clay. As the moulds are removed from the koondas, the weight may be greatly reduced by taking an adze, and paving the exterior into the form of a hexagon, corresponding

with the inside of the mould. When they are dry, holes should be made in the bottom, to correspond with the tenons on the wheel (Fig. 8) on which the hollow voussoirs are formed. By doing this before the burning, much labour is saved, the dry clay being easily cut with a chisel. The moulds may then be burnt. Litter is the best fuel for this purpose, wood creating too great a heat, and causing them to lose their shape from fusion.

Two coolies, after a few days' practice, will make from 6 to 8 moulds per day, and a carpenter can reduce the weight, and otherwise complete 15 in the same time. A great number are required, but this is only troublesome at first, for they last a long time. Those I made had been three months in use when I left Shikarpore, and had suffered no injury up to that time. If they do break, it is in the burning, or the first or second time they are used afterwards ; and the damage is always caused by carelessness in not mixing the clay well, or in not pressing it into the koonda sufficiently.

I used three different moulds for my vaults. They were radiated to suit spans of 8, 15, and 22 feet. I have now, however, discontinued those for the 8 feet span circular arc, as I intend making the vaults flatter. To enable the workmen to readily distinguish the different kinds, I inserted small pieces of wood into the bottoms of the wooden voussoirs. In this manner all the moulds are stamped, and, consequently, all the hollow voussoirs receive the same distinguishing mark as the wooden ones. I found this simple little precaution of very great use. Before commencing the mould making, the wooden voussoirs should be kept under water for two or three days, and afterwards they should never be allowed to dry; otherwise, from increasing or diminishing in bulk while they are being used, the moulds made with them will not be of the same size.

To make the hollow voussoirs, the clay used should be what is commonly called " strong earth," or what is used for pottery. It should be beaten into dust, and then mixed with

dry horse-dung, also beaten to dust. Water should then be added. An hour or two afterwards, when the clay is completely saturated, it should be well mixed with the hand, sufficient water being added to make it of the consistency of paste or putty, so that it can be taken up in the hand, and easily compressed into any form. It should remain in this state for twenty-four hours, after which it is fit for use.

The mould is filled in the same manner as the koonda. A piece of clay, taken from that before mentioned, is well worked up with the hands on a piece of plank, in the same way in which a native makes his bread. It is then beaten out with the palm of the hand into two flat cakes, which are carefully placed against opposite sides of the mould, and overlapping each other a little. The clay should then be well pressed into all the angles of the mould with the knuckles. After this, a piece of clay, about the size of an apple, should be thrown smartly to the bottom of the mould. If this is well done, it drives the clay previously placed most effectually into the acute angle at the bottom. The pressure of the knuckles is not sufficient there, and, moreover, this last piece of clay makes the circular wedge (Fig. 7) act more effectually. The mould is then placed on the wheel, and a small chip of wood (*a* Fig. 7), an eighth of an inch thick, inserted between the clay and the lower side of the mould. This is to prevent the wedge from making that side of the voussoir too thin. There is no necessity for a similar precaution for the other sides. An iron rod, like that previously mentioned, is then passed through the bottom of the mould into the top of the wheel. Next a circular wedge (Fig. 7), about half an inch less in diameter than the breadth of the mould, so as to leave round it about a quarter of an inch of clay for the thickness of the voussoir, and having a hole bored through it for the rod, is placed in the mould, and plenty of water sprinkled on it. The wheel, with the mould on it, is then set in motion with the foot, the wedge being firmly held with the hands, and gently pressed downwards.

If it descends very rapidly, it will be found, on taking it

out, that the cakes of clay are too thin: whenever this appears to be the case, more must be added with the hand. If the wedge does not descend to the bottom, it is owing to there being too much clay, and this will have accumulated under it. This should be removed, care being taken, in doing so, not to tear the sides of the voussoir. The hand should be conveniently placed against the clay, and the wheel set gently in motion. The surplus clay is neatly cut off in this manner. The wedge should then be again inserted, and the process continued, till the inside of the voussoir is perfectly smooth, and free from flaws. The wedge should be slowly removed from the mould, the wheel being kept in motion. The wedge ought to go to the bottom of the mould. This is ascertained by looking at the indentation made in the clay by the projecting piece at the bottom, and which is made to prevent the wedge descending too far, and destroying the bottom of the voussoir. It will be observed, from the manner in which the voussoir has been made, that the acute angle at the bottom is solid. This must be scooped out with the hand, and, at the same time, the water which collects there during the process above described should be removed with a piece of cloth.

The next process is the closing of the mouth. The surplus clay and chip of wood are first removed. A good piece of clay, tolerably stiff, is then rolled between the hands, until it is almost a foot long, and an inch in diameter. One end of this is attached to the mouth of the voussoir, and the wheel being set gently in motion, it is carried all round, and well joined to the voussoir, by pressing it and the side together with the thumb and the finger. This effected, the projecting clay is tightly held between the thumb and finger, and the wheel being kept in motion, the mouth is gradually closed. If there is not sufficient clay, a small cake about the size of a rupee should be gently placed on the aperture, and the escape of the air inside immediately stopped by adding water, and joining the cake to the clay previously placed. If this is not done quickly, the mouth will sink.

The mould containing the voussoir may then be placed in the sun to dry, and when the clay begins to stiffen, the mouth must be hammered flat, a small hole being made to allow the air to escape. In three or four hours the voussoir is sufficiently dry for removal from the mould; the mould being turned upside down, the voussoir drops out.

In four or five days the voussoirs are dry enough for burning. This is done in the same way as with common pottery. A layer of dry sheep's dung is first laid on the ground, and over this a layer of light litter. On this bed two layers of voussoirs are placed, and over the whole is another layer of litter, covered with ashes. The ashes prevent the flame from escaping too soon.

One coolie, with two assistants to fill the mould for him, will, after a month's practice, make 70 voussoirs per day. Allowing the first, in consideration of his skill ..... Rs.	0	2	6
And paying the assistants at the usual rate. (viz. 2 annas each)	0	4	0
We have Rs.	0	6	6

for the cost of making 70, or say 10 annas per 100.

Again, one "Buttee" maker, assisted by two coolies, will prepare a "Buttee" containing 700 voussoirs in a day. Allowing the buttee maker for his work, and for watching the buttee during the night ..... Rs.	0	5	0
Paying the assistants at the usual rate of two annas each ..... Rs.	0	4	0
And allowing one cart and a coolie 8 annas per day for two days for collecting litter..... Rs.	1	0	0
We have, Rs.	1	9	0

for the cost of burning 700, or say 4 annas per 100. Adding

this to the cost of making, we have 14 annas for the cost of making and burning 100 voussoirs.

Until the coolies are expert, of course the voussoirs cost more than the above; but if the work is only cautiously commenced, and the number of hands gradually increased, the difference is not very great. In my manufactory I employ the carpenter, who makes the wooden voussoirs, to superintend the mould making. I find this a good plan, as he readily detects flaws. I also employ a potter to show the coolies how to mix the clay.

In order to employ convicts to make voussoirs for a barrack for the police, I used two wheels: on one the convicts made the voussoir in the rough, on the other the surplus clay was removed, and the mouth closed by a potter. The potter finished 150 voussoirs per day, with ease, in this manner. I, however, found, that from the voussoirs being frequently left standing in an unfinished state, they were not so well made, the clay becoming too stiff. By giving a man a wheel, and making him do the whole of the work himself, he can be held responsible for the quantity and quality of his work.

The first voussoirs I made had a hexagonal interior, as well as exterior, and were formed outside a mould; one of my reasons for preferring the hexagonal voussoir being, that of all regular figures which fit accurately together, the hexagon is that which has the greatest area compared to the perimeter, and is therefore the lightest form that can possibly be chosen.

This peculiarity has been remarked in the honeycomb, the cells being hexagonal. After a great many trials, however, I was obliged to relinquish this form for the interior, as the voussoirs could not be made free from flaws. By the present method of making them, however, the object I had in view is partly attained by a natural process. It will be observed, that while the circular wedge is being forced into the mould, the sides of the voussoir undergo greater compression than the angles; consequently, when the wedge is removed, the

clay at the sides to a small extent expands again ; and this change is further carried out during the drying, for the clay being thickest at the angles, they shrink more than the sides.

Another object I had in view, viz. making all the sides of the same thickness, even at the bottom, where the voussoir is an elongated hexagon, is also attained by the present method. The circular wedge, being only steadied by the hand at the top of the voussoir, oscillates a little as the wheel is turned, and being almost equally checked in each direction by the clay, forms, provided the process is not continued very long, a circular aperture, which corresponds with the regular hexagon outside it. At the bottom, however, where the wedge is kept steadily in the centre by the iron rod, it forms an elliptical bore in its oblique section, a form which exactly suits the elongated hexagon. (Figs. 10 and 11.)

It may appear from the preceding description, that these voussoirs can only be made with clay of rare quality ; but I feel sure, that wherever the clay is good enough for common pottery, (and there are few places where it is not,) they can be made equally well.

The Construction of the Vault.

The haunches and end walls having been carried up to the requisite height, the first voussior is let into the end wall at the crown of the curve. (Fig. 12.) Other voussoirs at proper intervals are then similarly let into the wall, till the haunches are reached. About one-half of each voussoir ought to project outside the wall, and the interval between each should be sufficiently large for the reception of half a voussoir and its cement. The vaulting is then commenced at the angles, which are gradually filled in, each course of voussoirs being commenced at the end wall, and carried obliquely down to the haunch in the following manner. The sides of voussoirs 6 and 7 (Fig. 12), and the wall in front, being covered with cement, No. 8 voussoir is thrust in (care being taken in doing so to keep the top parallel to the direction of the vault) with

two or three blows from the hand. It penetrates like a wedge, making the joints quite smooth. After this, the joints should be closed above and below, to make them air-tight, till the clay has stiffened a little. No. 9 is then thrust into its place in the same way as No. 8, forcing the latter, if it is possible, still tighter into its place. This completed, No. 10 in the next course is placed; and so on throughout the whole length of the vault.

It will be observed, that by keeping the haunches of the vault advanced at this angle, any settlement at the crown is prevented. Two sides of each voussoir being perpendicular to the direction of the course, they are directly opposed to any settlement. The vault is kept in the proper curve by a circular piece of plank, standing on the projecting bricks of the cornice; and so little settlement takes place, that this can be made to slide back under the completed portion of the vault.

The voussoirs run about 450 to 100 square feet, and a workman tolerably expert can vault 40 square feet in a day. From the small number of voussoirs required, and the small quantity of cement used, he requires very little assistance.

In all the vaults constructed on this plan, mud and bhoosa has been the cement used, and it has been found quite sufficient. Being thrown against the voussoirs, and spread with the hand, it will be found more expeditious than chunam, and of course more economical.

With regard to the haunches, it is evident that they should be carried up as far as ever they will stand securely without the assistance of the thrust from the vault, for the more the centre of gravity of the wall and haunch is brought inwards in this manner, the greater is the stability of the structure when completed. I found from experiment that the haunches of a semi-circular vault of 15 feet span could be carried up to a height of 5 feet. To prevent accidents from a number of work-people congregating on them before the vaulting was commenced, I carried the haunches up to a height of 4 feet

in the first instance, completing them to the requisite height while the vaulting was being executed.

It appears to me impossible to apply the accurate theories of the arch to these vaults, the strength of the cement bearing so great a proportion to the weight. It is evident, moreover, that a portion of the vault is supported by the end wall against which it leans—it may be almost said to rest upon it.

The perfect manner in which the strain is distributed through the mass, owing to the hexagonal form of the vous-soir, and the peculiar bond arising from that form, and the obliquity making a rupture extremely difficult, also contribute to render calculation erroneous. Actual experiment must determine the extent to which the principle can be safely carried.

J. G. FIFE, *Lieutenant*,
Executive Engineer, *Upper Scinde*.

Kipree, West Bank of the Nara, 24th December 1851.

Developed plan of Vault in course of construction.

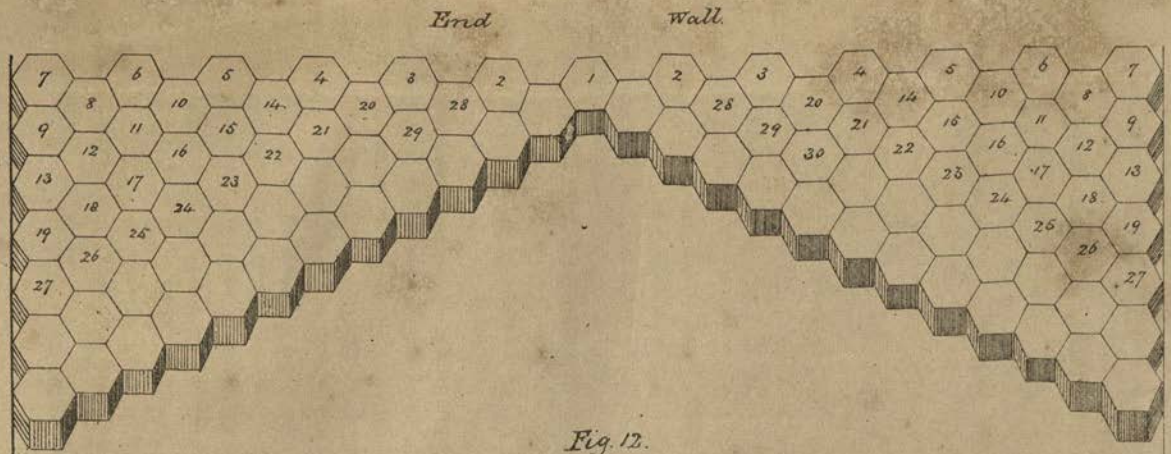

Fig. 12.

No. 3627 of 1852.

Public Works. General Department.

To the Secretary to the Military Board,

Bombay.

Sir,

I have the honor to submit the statement of expenditure in the construction and repair of public works from the 1st of May 1851 to the 30th of April 1852, amounting to Rupees 2,69,082 (two lacs, sixty-nine thousand and eighty-two).

2. The following are the names of the Officers who composed the department:—

Lieutenant Jenkin Jones, 1st Assistant.
Lieutenant W. Waddington, Acting 2nd Assistant.
Mr. Armitstead, 2nd Assistant.
Captain Macdonald, in charge Nagpoor dawk line of road.
Lieutenant J. A. Fuller, 2nd Assistant.
Mr. Scott, 2nd Assistant.
Lieutenant C. Scott, 1st Assistant.
Lieutenant J. S. Trevor, 2nd Assistant.

3. The expenditure during the year amounts to Rs. 2,69,082 (two lacs, sixty-nine thousand and eighty-two), whilst the cost of superintendence comes to 23¼ per cent. on that sum. By a reference to the reports for former years, it will be seen that the expenditure for the last year, as compared with the average of that for the two preceding years, has decreased to the extent of Rs. 88,758 (eighty-eight thousand, seven hundred and fifty-eight), whilst the cost of superintendence has increased from 19¼ to 23¼ per cent. The cause of the diminution in the expenditure is to be ascribed to three circumstances:—

1*st*.—The suspension of Lieutenant Scott's road from Kussara to Khurdee.

2*nd*.—The completion of the Thull Ghaut.

3*rd*.—The completion of the portions of the Poona and Sholapore road which had been sanctioned for a large amount.

4. I am happy, however, to remark, that the recommencement of the first work has been lately sanctioned, as also a large number of other works under different Assistants; and there is every prospect of the expenditure amounting during the present year to what it came to for the two preceding years.

5. I will now proceed to notice the works of importance which have been carried out under each of the Assistants. I shall not refer to the repairs of the roads in the department, which occupy so much of the time and attention of the different officers.

Works connected with the Communications of the Country.

Lieutenant Jenkin Jones, *1st Assistant, in charge of Public Works in the Poona Collectorate.*

6. The improving and widening of the mail road from Dapooree bridge to Akoordee has been completed, at a total cost of Rs. 10,256-4-3 (ten thousand, two hundred and fifty-six, annas four, and pies three). The road originally was only 20 feet wide; it is now 25 feet wide, and the raised portions of the road have been protected by means of mounds of earth, as a security against accidents. This portion of the road was in very bad order before it was widened. It is now about the best piece of road along the whole line from Poona to Panwell, which circumstance I ascribe to the wear and tear of the road having been diffused over a greater surface, and to the surface of the road having been kept as flat as possible.

7. A cross-road from Chakun, to join the mail road near Wurgaum, was sanctioned under date the 18th March 1851, for Rs. 12,800 (twelve thousand and eight hundred). Considerable progress was made in the execution of the road

during the year, and the traffic between Panwell and Ahmednuggur has already adopted this route, in preference to the old road *viâ* Lohgaum and Waghoolee.

8. A branch road, sanctioned under date the 31st October 1851, for Rs. 3,837 (three thousand, eight hundred and thirty-seven) has been opened out between the mail road and the city bridge at Poona, and it affords a direct communication between the two, which was much wanted. The work has been completed.

9. One double and four single drains on the Nimbadeerah Ghaut, beyond Ahmednuggur, have been built, at a cost of Rs. 320-9-5 (three hundred and twenty, annas nine, and pies five). The road was made many years ago, by means of prisoners, and these drains were left undone; in consequence of which carts were unable to adopt the new line of road which has now been made available.

10. A sum of Rs. 1,304-3-9 (one thousand, three hundred and four, annas three, and pies nine) has been expended during the year in marking out and improving the road up the Moota river in the direction of the Murrah Ghaut. The amount sanctioned was Rs. 3,000 (three thousand), derived from certain funds placed at my disposal by the Collector of Poona. The road was nearly impassable for carts before the new line was opened out. It is now much used, and has proved of much convenience to the public.

Lieutenant WADDINGTON.

11. This officer was appointed to the department under date the 18th October 1851, and he has been employed in the construction of two roads, one from Narraingaum to Jooneer, and the other from Narraingaum to the Alleh Khind, in the direction of Sungumnair and Nassick. These roads were sanctioned under date the 18th March 1851, at the rate of Rs. 800 (eight hundred) per mile. Curb stones have been dispensed with. The road has been very well drained through-

out, and, when completed, there will not be a dip along the whole line. Both roads have been considerably advanced.

12. I should also mention, that the road through the Alleh Khind, which was made some twenty years ago, has been put into thorough order. From its not having been repaired for years, it had got into a very bad state, and it was nearly impassable for carts. When the road is sanctioned as far as Sungumnair, and the Chundunpooree Ghaut is properly made, a direct communication for cart traffic between Nassick and the valley of the Godavery will be opened out with Poona and Panwell.

Mr. ARMITSTEAD, *2nd Assistant.*

13. This Assistant has been principally employed in the construction of the road from Poona towards Sholapore; and as nothing has been published regarding it for the last three seasons, it may be as well that I should show concisely what has been done up to the present time.

1st.—The first portion of the road from Indapore to Patus, a distance of 44 miles, 6 furlongs, and 17 yards, was sanctioned under date the 17th December 1845, for Rs. 2,54,732 (two lacs, fifty-four thousand, seven hundred and thirty-two), and it was commenced under date the 5th of February 1846. The road is 22 feet wide, well raised, levelled, bridged, and drained throughout, with the exception of the ten streams which require bridges of a large size to be built over them.

2nd.—The second portion of the road from Poona to Patus, a distance of 36 miles, 6 furlongs, and 170 yards, was sanctioned under date the 31st August 1848, for Rs 1,31,221 (one lac, thirty-one thousand, two hundred and twenty-one), and it was commenced under date the 1st November 1848. It is of a similar construction to the portion above described. It is completed, with the exception of fifteen bridges, which are required to be built over the large streams that intersect the line. The plans and estimates of these bridges have been submitted for sanction.

3rd.—The third portion of the road from Indapore to the Bheema river, a distance of 5 miles, 5 furlongs, and 100 yards, was sanctioned under date the 21st November 1850, for Rs. 20,711 (twenty thousand, seven hundred and eleven); it was commenced by the late Lieutenant Donne, and completed by Mr. Armitstead.

4th.—The fourth portion includes the continuation of the road from the Bheema river to Tunboornee, a distance of 7 miles, which was sanctioned under date the 15th January 1852, for Rs. 29,430 (twenty-nine thousand, four hundred and thirty); and the construction of the road on both sides of the Leena river was sanctioned under date the 21st November 1850, for Rs. 6,735 (six thousand, seven hundred and thirty-five). Considerable progress was made in the construction of both pieces of road during the official year, and it is expected that about four miles of road will be made beyond Tunboornee within the amount sanctioned.

It appears from the above statement, that 98 miles, 2 furlongs, and 67 yards of this road have been constructed in the course of the last six years; and the following Table shows the masonry works that have been executed on each portion of the line:—

List of Bridges and Drains built on

	Slabbed Drains.																		
	Single.					Double.						Three Water Ways.			Four Water Ways.		Five Water Ways.	Six Water Ways.
	Up to 1¾ Foot.	2 to 2¾ Feet.	3 to 3¾ Feet.	3¾ to 4½ Feet.	5 to 6 Feet.	1¾ Foot.	2 to 2¾ Feet.	3 to 3¾ Feet.	4 to 4½ Feet.	5 Feet.	6 Feet.	2¾ Feet.	4 Feet.	5 to 6 Feet.	4½ Feet.	6 Feet.	4½ Feet.	4½ Feet.
Poona to Patus	..	38	29	38	15	..	..	..	6	13	2	..	1	4	3	1	1	..
Patus to Indapore ..	30	85	42	23	2	3	6	18	18	..	..	1	4	..	..	..	..	2
Indapore to Bheema River	8	6	17	5	..	..	..	1	7	..	..	..	2	..	..	..	1	1
Bheema River to Yenegaum	2	6	12	3	..	..	..	2	1	..	..	..	..	..	..	..	..	1
Total....	40	135	100	69	17	3	6	21	32	13	2	1	7	4	3	1	2	4

Remarks.—Total length of road from Poona to Yenegaum 98 miles, 2 furlongs, and 67 yards.

Masonry	slabbed drains of sizes....	460
,,	culverts of sizes.....	32
,,	bridges	19
,,	,, 2 arches	1
,,	,, 3 ,, ...	1

the Road from Poona to Yenegaum.

ARCHED CROSSINGS.																Remarks.
Culverts.				BRIDGES.												
Single.				Single.									Double.		Three Water Ways.	
5 Feet.	6 Feet.	8 Feet.	9 Feet.	10 Feet.	12 Feet.	15 Feet.	16 Feet.	20 Feet.	21 Feet.	25 26 Feet.	34 Feet.		14 Feet.	15 Feet.	16 Feet.	
..	..	..	3	..	..	1	..	..	..	2	1		1	..	..	
13	8	6	1	4	3	1	3	2	1	..	..		..	1	1	Nineteen aqueducts for garden irrigation are not included under the works of road drainage.
..	..	..	..	..	..	..	..	..	..	..	..		..	..	..	
..	..	1	..	..	..	..	..	..	1	..	..		..	..	..	
13	8	7	4	4	3	2	3	2	2	2	1		1	1	1	

(Signed) T. P. ARMITSTEAD,
2nd Assistant Superintendent of Roads.

14. Roadways have been cleared from the main line to the seven travellers' bungalows between Poona and Indapore, at a cost of Rs. 275-4-9 (two hundred and seventy five, annas four, and pies nine).

15. The bullock track over the Deweh Ghaut, between Poona and Sassoor, sanctioned under date the 20th February 1850, for Rs. 500 (five hundred), has proved of great convenience to the public, and numerous carts even prefer this route to the road over the Bapdeo Ghaut. A new line down this ghaut has been marked out, with a slope of 1 in 20, and the sanction for its construction is daily expected.

16. *Captain* MACDONALD succeeded the late Captain Dennis in charge of the dawk road from Ahmednuggur to the Wurda river, in the direction of Nagpoor.

17. Independent of the repairs to this line of road, which are principally made to facilitate the dawk from Calcutta to Bombay, more particularly during the monsoon, a number of masonry, wooden, and flying bridges have been constructed, at an aggregate cost for the years 1850-51-52 of Rs. 4,914-15-6 (four thousand, nine hundred and fourteen, annas fifteen, and pies six); and a fair weather road has been cleared between the Godavery and the Wurda river, the cost of which has amounted on the whole to Rs. 12,237-1-4 (twelve thousand, two hundred and thirty-seven, anna one, and pies four). The work is completed.

Lieutenant FULLER, *in charge of Roads in the Northern and Southern Concan.*

18. No new roads or bridges have been carried into execution by this officer during the past Official year.

Mr. SCOTT, *in charge of Roads in Salsette.*

19. No new roads have been carried into execution by this Assistant during the past official year, but a number of small works in connection with the communications of the country under his charge have been performed.

20. The Dysur, Goregaum, and Sanky bridges, on the Ghorebunder road, have been enlarged, and their respective approaches improved. A raft has been provided for the Colsette ferry, at a cost of Rs. 1,107 (one thousand, one hundred and seven), and a horse-boat for the ferry between Ghorebunder and Bassein, at a cost of Rs. 1,276 (one thousand, two hundred and seventy-six), whilst several of the other ferry boats have been extensively repaired, and the ferries generally are now well provided with boats. A new horse-boat for the ferry at Satputty is in course of construction, at an estimated cost of Rs. 1,500 (one thousand and five hundred).

21. Milestones have been put up on the Bandoop and Tanna road, at a cost of Rs. 13–11–8 (thirteen, annas eleven, and pies eight).

Lieutenant SCOTT, *in charge of the new Road from Kussarah to Khurdee, and of the Line from thence to Colsette and Kusseylee Bunders.*

22. The sanction of the new line of road was suspended during the past year, pending a reference to the Government of India, and the extensive works along the line were stopped, with the exception of the viaduct over the Mokhownah river, which was carried up to the springing of the arches. The amount expended thereon during the year came to Rupees 5,059–12–7 (five thousand and fifty-nine, annas twelve, and pies seven). The sum sanctioned for 12 miles, 7 furlongs, 95 yards, and 2 feet of road, comes to Rs. 2,55,849 (two lacs, fifty-five thousand, eight hundred and forty-nine), and the amount already expended to Rs. 1,17,138–5–4 (one lac, seventeen thousand, one hundred and thirty-eight, annas five, and pies four). It is expected that the greater portion of the line will be opened to the public by the next monsoon.

23. The steps to the bunder at Kusseylee have been repaired, at a cost of Rs. 138–10–2 (one hundred and thirty-eight, annas ten, and pies two). Land-slips have been removed on the 1st division of the new road, at a cost of

Rs. 517–1–4 (five hundred and seventeen, anna one, and pies four), and temporary bridges have been erected across all the impassable nullas below the ghaut, for the convenience of the mail during the monsoon, at a cost of Rs. 155–10–6 (one hundred and fifty-five, annas ten, and pies six).

24. *Lieutenant* TREVOR succeeded Lieutenant Chapman, under date the 13th August 1851, in charge of the roads and public works in the Nassick Sub-Collectorate.

25. The Undwell bridge, of 100 feet span, built by *Lieutenant* CHAPMAN, was completed in January 1852, and its cost, exclusive of approaches, came to Rs. 16,444–8–4 (sixteen thousand, four hundred and forty-four, annas eight, and pies four).

26. It would be too tedious to mention separately all the new works which have been sanctioned on the great Agra road, between the Thull Ghaut and the limit of the Candeish boundary, more particularly as most of them were only commenced at the beginning of the present year, and will not be completed for the next twelve months. I should observe, however, that they are comprised of a number of large bridges over the Wakee, Kaprah, and Waldevi rivers, designed by Lieutenant Trevor, besides several extensive alterations to the present road between the Thull Ghaut and Nassick, and small bridges and drains over many of the nullas that are at present unbridged, the names of which are all specified in the statement of the expenditure.

27. Numerous other bridges on the same line have since been sanctioned, and the estimates for nearly every improvement required have been submitted. I shall, therefore, merely add, that the greater part of the road will most likely be furnished from the Thull Ghaut to Nassick by the next monsoon, by which time all the large bridges will have been finished, and opened to the public, with the exception of that over the Nassurdee river, close to Nassick.

28. I will now merely refer to a few of the works which

Lieutenants Chapman and Trevor conjointly carried into execution during the past year.

29. The flying bridge at the Kadoo river, between Nassick and Chandore, was completed in May 1851; the amount expended on the whole came to Rs. 651–11–0 (six hundred and fifty-one, and annas eleven). The work consisted of new masonry ramps on each side of the river.

30. Constructing a ford with approaches near the site of the new flying bridge at Nassick has been nearly completed, and has for a long time past been open to the public. This work was designed by Lieutenant Chapman, and is a great improvement to this portion of the line of road.

31. The new flying bridge, also, connected with the above work, was completed in June 1851, for Rs. 9,418–10–11 (nine thousand, four hundred and eighteen, annas ten, and pies eleven).

32. A new boat has been built for the ferry at Sungumnair, at a cost of Rs. 604–8–2 (six hundred and four, annas eight, and pies two).

33. The principal improvement carried into execution during the year on the Agra road was the construction of a new piece of road, for the purpose of removing a steep and dangerous ascent near the town of Chandore; and, though not quite finished in April last, it was then open to the public. The work has been very well done, and a small skew bridge has been built over the nulla at the foot of the ascent, both of which works do Lieutenant Trevor infinite credit.

34. The improvement also to the Agra road has been continued during the year, from a sanction which has been periodically granted to the extent of Rs. 9,000 (nine thousand), and the road has now been widened, levelled, and drained from the top of the Thull Ghaut to a spot near the Wakee and Kaprah rivers, a distance of 5 miles, 141 yards, and 2 feet.

35. The Undwell bridge was connected with the old line of road, at a cost of Rs. 902–6–1 (nine hundred and two,

annas six, and pie one), to meet the convenience of the public during the monsoon, and the few remaining improvements to the Thull Ghaut sanctioned after the line was opened were completed at a cost of Rs. 8,678 (eight thousand, six hundred and seventy-eight).

36. The roads in the Peinth States were made over to the charge of Lieutenant Trevor, under date the 21st November 1851; and the road from Sawul Ghaut to Oomralla, and its continuation to Peinth, as also the road from the Suttee Ghaut to Hursole, have, with the exception of the latter, been advanced to as great an extent as the sanctions would permit.

Tanks, Bunds, and Wells.

37. *Lieutenant* Jenkin Jones has incurred an expenditure of Rs. 4,065–9–6 (four thousand and sixty-five, annas nine, and pies six), in the construction and repairs of tanks, bunds, and wells in the Poona Collectorate.

38. The Jooneer aqueduct has been cleaned out and thoroughly repaired, at a cost of Rs. 950–5–1 (nine hundred and fifty, annas five, and pie one). It is an old aqueduct, which had fallen into decay. It is intended to afford water to the inhabitants of Jooneer, and it now furnishes a very fair supply.

39. The aqueduct leading to the Hafiz Bagh, near Jooneer, another old Mahomedan work, is intended for irrigation, and it has been partially repaired, at a cost of Rs. 978–13–6 (nine hundred and seventy-eight, annas thirteen, and pies six). It has been necessary, however, to submit a fresh estimate for the completion of the work, which has been duly sanctioned, under date the 19th of March 1852.

40. A well at Loonee, for the use of travellers, has been built, at a cost of Rs. 421–8–11 (four hundred and twenty-one, annas eight, and pies eleven).

41. The large tank or reservoir in the Civil Lines at Poona has been deepened, and the stone used for the purpose

of filtering the water, at a cost of Rs. 368–15–8 (three hundred and sixty-eight, annas fifteen, and pies eight). This water, which is the drainage of a part of the cantonment, has been so purified by means of cleaning out the tank, and filtration, that it is now used by most classes for drinking and cooking purposes.

42. The aqueduct which conveys water from the Katruz tank to the city of Poona has been cleaned out, and the work has been completed, and the supply thereby somewhat increased. An experiment was sanctioned for the purpose of ascertaining whether an increased supply of water could be obtained for the use of the Katruz and Kondwah aqueducts, near to Poona, which has turned out very favourably, and the result will be made known in a future report.

43. *Lieutenant* WADDINGTON made some repairs to the Narraingaum dam, at a cost of Rs. 77–3–8 (seventy-seven, annas three, and pies eight), which have succeeded in stopping a considerable leakage that occurred in some parts of the aqueduct.

44. *Lieutenant* FULLER. This Officer has completed the repairs of the Wuddalah tank, at Panwell, and it holds water very well now, and does not leak. He has also built a ramp at the Panwell bunder, for the purpose of landing carriages and horses, and he has been employed in the construction of a masonry dam at Wasee, for the purpose of irrigating the salt-pans at that place, from which a large revenue is yearly derived. An excess is likely to occur in the completion of this work, which has been caused in different ways, one of which was the giving way, on three different occasions, of the earthen dam thrown up for the purpose of keeping out the tide.

45. *Mr.* SCOTT has executed some petty works in Salsette, and he has built a sluice-gate to the Government Khar at Bhinder, near Ghorebunder, at a cost of Rs. 234–9–5 (two hundred and thirty-four, annas nine, and pies five). The work has been completed satisfactorily.

46. *Lieutenant* SCOTT has completed the dam across the Ruttoondah, which he built the year before, and he has opened out two wells, one at Kussarah, and the other half way between that place and Khurdee, both of which have answered very fairly ; but in the month of May the supply is not so good as it was expected to be.

47. *Lieutenant* TREVOR. This Officer has constructed and repaired several bundaras in the Nassick Sub-Collectorate, at a cost of Rs. 2,131–12–2 (two thousand, one hundred and thirty-one, annas twelve, and pies two), and he has sunk a well near the top of the Thull Ghaut, which will prove of great convenience to travellers and cartmen, it being close to a great halting place.

BUILDINGS.

48. *Lieutenant* JENKIN JONES has incurred an expenditure of Rs. 4,748–5–6 (four thousand, seven hundred and forty-eight, annas five, and pies six) in the construction and repair of the buildings under his charge. The most important seem to be the addition of bath-rooms and necessaries to the travellers' bungalow at Poona, and the construction of arm-racks and shelves to the different staging pendalls above the Ghaut, at a cost of Rs. 1,666 (one thousand, six hundred and sixty-six). The other works are, more or less, of a petty kind, requiring no particular notice.

49. *Mr.* ARMITSTEAD has finished the building of the fine new travellers' bungalow between Poona and Indapore ; and the one at Jeejooree, on the same plan, was nearly completed in April last. These buildings have two sitting-rooms, with a verandah all round, and a bath-room and necessary at each end of the verandah, on the rear side. They are built entirely of masonry ; and the estimated cost, including out-houses, comes to Rs. 2,117 (two thousand, one hundred and seventeen).

50. Furniture has been provided for all the buildings, at the cost specified in the statement.

51. *Lieutenant* FULLER has finished the construction of the new travellers' bungalows at Mhar and Nagotna, and they are both very nice buildings. The estimated cost came to Rs. 4,736 (four thousand, seven hundred and thirty-six), and the one at Mhar to Rs. 4,498 (four thousand, four hundred and ninety-eight). Both have been completed within the estimates.

52. The arm-racks and shelves to the staging pendalls below the Ghauts have been completed, and the furniture supplied to the new bungalows above mentioned, for the sums specified in the statement.

53. New police lines have been built at Penn, at a cost of Rs. 370 (three hundred and seventy).

54. *Mr.* SCOTT has incurred an expenditure of Rs. 5,076-10-3 (five thousand and seventy-six, annas ten, and pies three) in the construction and repairs of the buildings under his charge, none of which are of that importance as to require particular notice, with the exception of a number of pendalls or chowkies, which he has built for the police in different parts of Salsette, and which have been completed at a cost of Rs. 1,346 (one thousand, three hundred and forty-six).

55. *Lieutenant* SCOTT, *1st Assistant*, has expended the sum of Rs. 925-3-3 (nine hundred and twenty-five, annas three, and pies three) in the repair of the buildings under his charge.

56. *Lieutenant* TREVOR has incurred an expenditure of Rs. 2,759-8-9 (two thousand, seven hundred and fifty-nine, annas eight, and pies nine) in the buildings under his charge. A building for stores, and the use of Overseers, has been built half way between Nassick and Chandore, at a cost of Rs. 712-13-4 (seven hundred and twelve, annas thirteen, and pies four); and the travellers' bungalow at Egutpoora has been altered and much improved, at a cost of Rs. 994-6-1 (nine hundred and ninety-four, annas six, and pie one).

57. The above concludes the remarks that I have to offer regarding the works which have been carried into execution during the preceding year in this Department; and the only

thing now left for me to add is, that I have every reason to feel pleased with the exertions made by the Assistants and their subordinates in the execution of the works entrusted to their charge.

I have the honor to be,
Sir,
Your most obedient Servant,
W. D. GRAHAM, Brevet Captain,
Superintendent of Roads and Tanks.

Poona, Superintendent of Roads' Office,
25th December 1852.

Comparative Statement showing the Expenses of Engineering and Superintendence on account of the Road and Tank Department, for the Year 1851-52.

Names.	Staff Salary.	Extra Batta.	Regimental Allowances, less Nett Pay.	Permanent Establishment.	Total.	Other Expenditure.	Gross Expenditure.	Per-centage of Staff salary, Extra Batta, Regimental Allowances, less Nett Pay, and Permanent Establishment, on Gross Expenditure.
	Rs. a. p.	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	
Captain Cowper, 1st Assist. Supt. of Roads	818 11 4	....	....	....	4,561 7 11	54,832 9 1	59,394 1 0	7·680
Lieutenant Jenkin Jones, 1st Assist. Supt. of Roads ..	1,410 0 0	....	....	2,332 12 7				
Lieutenant Waddington, 2nd Assist. Supt. of Roads ..	1,896 0 0	....	....	360 0 0	2,256 0 0	4,041 14 8	6,297 14 8	35·821
Mr. Armitstead, 2nd Assist. Supt. of Roads	77 6 8	1,488 0 11	....	2,572 1 7	4,137 9 2	58,038 14 4	62,176 7 6	6·654
Captain Dennis, Post Master, in charge Nagpore Dawk Line	3,609 7 8	....	....	2,198 5 6	7,651 9 2	18,556 7 7	26,208 0 9	29·195
Lieutenant Bird, Acting Post Master, in charge Nagpore Dawk Line	984 12 4	....	....	488 7 8				
Captain Macdonald, Post Master, in charge Nagpore Dawk Line	118 8 0	....	....	252 0 0				

Names.	Staff Salary.	Extra Batta.	Regimental Allowances, less Nett Pay.	Permanent Establishment.	Total.	Other Expenditure.	Gross Expenditure.	Per-centage of Staff Salary, Extra Batta, Regimental Allowances, less Nett Pay, and Permanent Establishment, on Gross Expenditure.
	Rs. a. p.	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	*Rs. a. p.*	
Lieutenant Fuller, 2nd Assist. Supt. of Roads ...	4,740 0 0	....	....	4,053 10 4	8,793 10 4	28,811 0 8	37,604 11 0	23·383
Mr. Scott, 2nd Assist. Supt. of Roads	5,640 0 0	....	....	3,578 13 1	9,218 13 1	31,458 3 3	40,677 0 4	22·663
Lieutenant Scott, 1st Assist. Supt. of Roads	6,484 5 7	....	....	6,148 9 10	12,632 15 5	20,668 12 4	33,301 11 9	37·934
Lieutenant Chapman, 1st Assist. Supt. of Roads ...	1,895 10 8	....	....	1,514 15 8	13,394 10 2	52,674 11 4	66,069 5 6	20·273
Lieutenant Trevor, 2nd Assist. Supt. of Roads ...	4,740 0 0	....	....	5,243 15 10				

W., D. GRAHAM, Brevet Captain,
Superintendent of Roads and Tanks.

Camp Chakun, Superintendent of Roads' Office,
18*th January* 1853.

Statement of Expenditure in the Construction and Repair of Public Works in the Road and Tank Department, from the 1st of May 1851 to the 30th of April 1852.

Superintendent of Roads' Office, Poona, 25th December 1852.

Names of Works.	Amount.	Total.
	Rs. a. p.	*Rs. a. p.*
Works connected with the Communications of the Country	.....	2,31,464 10 7
Including—		
Annual repairs to roads, bridges, &c. for 1850-51	6,274 4 8	
Improving and widening the Akoordee road..	8,283 6 1	
Annual repairs to roads, bridges, &c. for 1851-52	15,643 10 10	
Ditto to roads from Poona to Seroor, for 1851-52	3,557 5 5	
Constructing a new cross-road from Chakun *viâ* Tullegaum, to join the Poona mail road.	3,385 13 1	
Constructing a new road from the old Panowlee road to join the present Poona mail road, and widening the road from new Poona bridge to old Panowlee road	2,493 11 10	
Annual repairs to roads, bridges, &c. for 1851-52, in the Ahmednuggur Collectorate	3,784 4 9	
Constructing one double and four single drains on the road from Nuggur to Neembadeera.	320 9 5	
Improving Murra Ghaut road	1,304 3 9	
Making a road from Narraingaum to Jooneer.	1,906 1 2	
Do. do. do. do. to Alleh Khind.	1,340 11 0	
Constructing a new line of road between Poona and Patus	14,371 0 0	
Constructing a new line of road between Indapore and Bheema	17,583 14 10	
Constructing a new line of road between the Bheema river and Timboornee	2,836 10 1	
Annual repairs to main road from Poona to Patus, for 1851-52	7,712 10 5	
Do. do. from Patus to Indapore, for 1851-52	5,311 10 0	
Do. do. from Poona to Neera bridge, for do.	2,711 5 4	
Fixing standards from Poona to Neera bridge.	1,060 14 2	
Annual repairs to masonry, wooden, and flying bridges on the Nagpore dawk line, for 1851-52	5,868 9 1	

Names of Works.	Amount.			Total.		
	Rs.	a.	p.	Rs.	a.	p.
Building masonry, wooden, and flying bridges for the year 1850-51	2,191	4	6			
Maintenance of ferrymen and haulers along the dawk line of road, for 1851-52	3,297	3	11			
Clearing a fair weather road between the Godavery and the Wurda river	4,222	1	8			
Building masonry, wooden, and flying bridges, for the year 1851-52	2,723	11	0			
Annual repairs to mail road, for 1851-52	5,425	3	1			
Do. to cross roads in the Northern Konkun, for do.	3,412	8	2			
Do. to main road for do.	4,572	9	1			
Do. to cross roads in the Southern Konkun, for do.	1,691	9	1			
Improving the Dhysur, Ghoregaum, and Sankey bridges, and their respective approaches on the Ghorebunder road	1,519	1	8			
Constructing a horse boat for the ferry between Ghorebunder and Bassein	1,026	0	0			
Repairing the ferry boats at Oomergaum and Dhanoo	1,007	0	0			
Annual repairs to the several lines of roads in Salsette, for 1851-52	19,407	2	5			
New line of road between Kussara and Khurdee	5,059	12	7			
Annual repairs to main road, for 1851-52	11,980	5	8			
Building a bridge over the Undwell river and approaches	1,777	15	4			
Constructing a bridge over the Waldevi river.	1,282	12	11			
Do. bridges over the Wakee and Kaprah rivers, and over a nulla near Egutpooree, and making a new road on both sides	1,441	0	2			
For constructing ford, with approaches, near the site of the new flying bridge at Nassick.	1,524	1	11			
For the new flying bridge over the Godavery river, at Nassick	3,041	15	6			
For removing a steep and dangerous ascent on the great Agra road, near the town of Chandore	3,894	3	5			
For the improvement of the portions of the Agra line of road between the Thull Ghaut and Chandore Ghaut	8,853	6	3			
Annual repairs to the completed portions of the road between Kussarah and Egutpoora, for 1851-52	1,895	4	0			
Repairs to main road in the Nassick Sub-Collectorate, for 1851-52	13,427	15	4			
Do. to cross road in the Nassick Sub-Collectorate, for 1851-52	1,883	8	7			
Making a new road from Sawull Ghaut to Oomeralla	3,724	7	11			

Names of Works.	Amount.			Total.		
	Rs.	*a.*	*p.*	*Rs.*	*a.*	*p.*
Tanks, Bunds, and Wells.....	.....			10,711	4	8
Including—						
Repairs to Jooneer aqueduct	861	6	1			
Do. to Hafiz Baugh aqueduct, at Jooneer.	978	13	6			
Clearing out the aqueduct which conveys water from the Katruz tank to the city of Poona	1,210	13	11			
Constructing a ramp at the end of the Panwell bunder	897	0	0			
Do. a dam with sluice over the creek near the village of Wassee....	766	7	5			
Do. a well at Kussarah	574		5			
Building a bundara at the village of Loneewarra	680	14	5			
Sinking a well at Tullegaum, between the Thull Ghaut and Egutpoora	669	9	10			
Repairing a bund at the village of Boralah, Talooka Dindooree	539	14	1			
Buildings	.....			26,906	10	0
Including—						
Construction of bath-rooms and necessaries to Poona travellers' bungalow.....	810	0	0			
Arm-racks and shelves to staging pendalls.	1,666	0	0			
Annual repairs to travellers' bungalow in the Ahmednuggur Collectorate, for 1851-52 ..	620	0	0			
Erecting five travellers' bungalows between Poona and Indapore	3,375	8	9			
Do. a new travellers' bungalow at Jeejooree	645	10	10			
Constructing a new travellers' bungalow at Mhar	3,276	8	5			
Do. do. do. at Nagotnah.	3,763	15	9			
Erecting pendalls for certain of the police parties stationed in Salsette	696	0	0			
Petty repairs for 1851-52	2,102	1	3			
Grand Total Company's Rupees two lacs, sixty-nine thousand, and eighty-two, Annas nine, and Pies three.....				2,69,082	9	3

W. D. GRAHAM, Brevet Captain,
Superintendent of Roads and Tanks.

Statement showing the Amount expended by each Officer of the Road and Tank Department, from the 1st May 1851 to the 30th April 1852.

Names of Officers.	Roads and Bridges.			Tanks, Bunds, and Wells.			Buildings.			Total.		
	Rs.	*a.*	*p.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*	*Rs.*	*a.*	*p.*
Lieutenant Jenkin Jones	46,018	12	10	4,065	6	9	4,748	5	6	54,832	9	1
Lieutenant W. Waddington	3,964	11	0	77	3	8	.....			4,041	14	8
Mr. Armitstead	53,231	7	0	109	13	4	4,697	10	0	[illegible]		
Captain A. Macdonald	18,556	7	7	.....			.....			[illegible]		
Lieutenant J. A. Fuller	18,184	2	6	1,927	9	11	8,699	4	3	[illegible]		
Mr. Scott	26,069	3	8	312	5	4	5,076	10	3	31,458	3	3
Lieutenant C. Scott	18,516	15	6	1,226	9	7	925	3	3	20,668	12	4
Lieutenant J. S. Trevor	46,922	14	6	2,992	4	1	2,759	8	9	52,674	11	4
Total....Company's Rupees	2,31,464	10	7	10,711	4	8	26,906	10	0	[illegible]		

W. D. GRAHAM, Brevet Captain,
Superintendent of Roads and Tanks.

Statement showing the Expenses of Engineering and Superintendence with reference to actual Outlays.

Names of Officers.	Expense of Establishment per Annum.	Expenditure.	Rate per Cent.
	Rupees.	*Rupees.*	*Rupees.*
Lieutenant Jenkin Jones	4,561	54,832	$8\frac{1}{4}$
Lieutenant W. Waddington	2,256	4,041	$55\frac{3}{4}$
Mr. Armitstead	4,137	58,038	$7\frac{1}{8}$
Captain A. Macdonald	7,651	18,556	$41\frac{1}{5}$
Lieutenant J. A. Fuller	8,793	28,811	$30\frac{1}{2}$
Mr. Scott	9,218	31,458	$29\frac{1}{4}$
Lieutenant C. Scott	12,632	20,668	$61\frac{1}{10}$
Lieutenant J. S. Trevor	13,394	52,674	$25\frac{2}{5}$

Total Expenditure during the year.....	Rs.	2,69,082
Cost of Establishments do.		62,642
Average rate per cent.		$23\frac{1}{4}$

NOTE.—Captain Macdonald is Postmaster as well as in charge of the Nagpore dawk line, and the allowances drawn by that Officer should not therefore be all debited to the Road and Tank Department, especially as his engineering duties are confined to one line of works.

W. D. GRAHAM, Brevet Captain,
Superintendent of Roads and Tanks.

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